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SENATE

No. 289

REPORT
OF THE
COMMISSION ON WATERWAYS AND PUBLIC LANDS
ON THE
WATER RESOURCES
OF
THE COMMONWEALTH OF MASSACHUSETTS
THEIR CONSERVATION AND UTILIZATION
TOGETHER WITH THE
REPORT OF THE ENGINEER OF THE COMMISSION
1918.

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The Commonwealth of Massachusetts.

REPORT OF THE COMMISSION ON WATERWAYS AND PUBLIC LANDS.

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts.

Chapter 113 of the Resolves of 1915 provided for "an investigation of the matter of conserving and equalizing the flow of water in the rivers and streams of the Commonwealth", as follows:—

Resolved, That the board of harbor and land commissioners is hereby authorized and directed to investigate the matter of conserving, utilizing and equalizing the flow of water in the rivers and natural streams of the commonwealth, and may expend in carrying out the purposes of this resolve during the years nineteen hundred and fifteen, nineteen hundred and sixteen and nineteen hundred and seventeen, a sum not exceeding twenty thousand dollars, in addition to the unexpended balance of the appropriation made to carry on the investigation authorized by chapter ninety-five of the resolves of the year nineteen hundred and fourteen; but not more than ten thousand dollars shall be expended in any one year except that an unexpended balance in any year may be used in the succeeding year for the same purpose. Nothing herein contained shall be construed as applying to any river or natural stream under the jurisdiction and control of any state board or commission other than the board of harbor and land commissioners. Said board shall report to the general court, in print, the results of its investigations and its recommendations. [Approved May 20, 1915.

Complying with the provisions of this resolve, the Commission on Waterways and Public Lands has continued the work begun under its predecessor, and conditions found in connection with this investigation are set forth in detail in the supplementary pages following the conclusions and recommendations of the commissioners. From the data contained in the supplementary

report it will be found that an exhaustive study has been made by the Commission and its agents.

The conclusions of the Commission and the recommendations called for by the resolve are respectfully submitted herewith.

At the outset it may be said that the water power resources of Massachusetts are developed to a higher percentage of their possibilities than almost any other State in the Union. Nevertheless, there are opportunities for the utilization of water that now goes to waste, both in developed and undeveloped privileges.

There is a loss of unused water due to lack of storage and a loss due to lack of development. The more apparent storage possibilities have been described, and it is evident that some of the losses due to short hours of operation may be saved by an extension of the consumption of power generated by water, through a better co-ordination of steam and water power units. A further extension of this principle may also assist in the utilization of many undeveloped privileges. We must also not lose sight of the fact that every undeveloped water privilege has two possibilities, — one, the creation of power at the site of the development; the other, the conservation of water to be converted into power at some other site. The most efficient creation of power requires the largest possible utilization of the available head, but this involves considerations of cost and ultimate value of the product, calling for a special study of each situation, and making it very hard to lay down a rule that will apply with equal efficiency to all cases. It is a fact, however, that the transmission of electricity has made it possible to utilize water powers that otherwise would have little value as a practicable business proposition.

The formulation of a workable recommendation as to how Massachusetts may not only conserve but secure the fullest utilization of its water resources involves a careful consideration of various interests. Viewed in a broad light, the benefit to the Commonwealth will be very much the same as that derived from the development of any natural resource, and therefore it should not be the subject of any form of tax levied by a supervisory board on the assumption that it is a resource in which all the State has a right to share. On the contrary, because of

the fact that most water-power developments that now exist have been the primary factors in creating the communities where they are located, it would seem as if any further development might very properly be carried on as a direct benefit to the particular community, with the parties directly concerned bearing a large part of any expense involved.

It is realized that any plan that would provide for the complete use of the water resources of the State must take into account present private ownership in streams, flowage rights, existing developments and those that may be pending. For the State to take, from the individual, property that he has acquired through years of development, even though he may be making only a partial use of its possibilities, involves serious legal difficulties as well as serious financial problems. We are, however, impressed by the fact that there are streams not fully developed, that there is a considerable waste of water that should be converted into power, and that there are difficulties in the way of this accomplishment which the private individual or corporation cannot overcome. A situation exists in which the State can assist by co-operation with local owners in the utilization of resources that are now going to waste, in some cases by direct action through the use of the authority of the Commonwealth, in other cases through aid rendered to private parties.

For example, a considerable amount of power can be developed on the Millers River, and private capital was prepared at one time to make the development. Without going into details of the history of this enterprise, it is sufficient, for the purpose of illustrating one phase of the difficulties that may arise in the development of water resources, to say that the effort failed because it was not commercially possible to derive an adequate return upon the investment without some income from the use that would be made of the stored water by the wheels of mills whose owners had not assumed any part of the expense. It was necessary to get a return from the use of the water by those plants to whom it would ultimately flow; but the Legislature did not consider it desirable to give the owners of the undeveloped water the arbitrary power to determine who were the beneficiaries and how much they should pay. The

case cited is typical of other situations, and demonstrates the necessity for giving authority to a controlling commission to direct the development of those streams, and apportion the costs where the benefits will accrue to more than one party; and further demonstrates the necessity of having co-operation in order that the fullest possible use may be made of the water to be conserved.

Then, again, there may be a number of ownerships in the natural locations for conservation of the upper reaches of a river which, for various reasons, cannot be brought together for their development. Under these conditions some State commission should have authority to acquire such locations as may be needed, and to either finance their improvement directly by the State, or lease them for development to responsible parties under such terms as may be necessary to conserve all the water involved and secure its equitable distribution.

There is also the question of utilizing the power that is wasting over the dam while the plants that run only eight or ten hours out of the twenty-four are shut down. While this condition is primarily due to lack of pondage, and will be reduced by the creation of storage reservoirs on the upper reaches of the streams, there are cases where the lost water can be converted into power and sold under a comprehensive co-ordination of the power users. The solution of this problem offers the greatest field for the supervisory assistance of the State to secure not only conservation of the water power but the maximum efficiency in its use.

Recognizing many of the conditions associated with water conservation, in addition to those above referred to, the Commission on Waterways and Public Lands is convinced that the time has come for the State to assume such supervisory control of water powers now developed and of water resources capable of development as shall guarantee to the people of the Commonwealth seriously concerned in this source of natural power the fullest possible use of every available water resource.

The task of carrying out the right plan of co-ordination between the different types of public service involved is not an easy one, and only through the fullest possible co-operation on the part of all interested parties can results at all approaching

satisfactory standards be secured. The Commonwealth must approach any new responsibility for giving assistance to the great water-power companies of the State in a hearty spirit of appreciation for what has already been done by these constructive forces in utilizing one of the State's most important resources. The ability of the engineers of these great companies must be recognized, not only for what they have already accomplished, but in connection with the important work to be done in the future. On the other hand, the private parties who have thus far had the responsibility for development must recognize the prevailing tendency which seeks to restore to the people their control of all natural resources for the purpose of securing their largest possible use.

To produce the most efficient possible service from the State's water resources, we believe the time is ripe for the establishment of a system of State supervision as substantially set forth in the bill presented herewith, respectfully brought to the attention of the Legislature.

JOHN N. COLE,
JESSE B. BAXTER,
WILLIAM S. McNARY,
Commissioners.

FEB. 15, 1918.

AN ACT TO ENLARGE THE POWERS OF THE COMMISSION ON
WATERWAYS AND PUBLIC LANDS, AND TO PROVIDE FOR THE
DEVELOPMENT AND USE OF THE WATER-POWER RESOURCES
IN THE COMMONWEALTH.

Be it enacted, etc., as follows:

SECTION 1. In addition to all the powers now conferred upon it, the commission on waterways and public lands shall have general care and supervision of such water power and water resources within the commonwealth as are or may be capable of further development or utilization; it shall from time to time investigate the same, prepare plans and devise methods for such development or utilization, and in its annual report incorporate the results of such studies, with its recommendations thereon.

SECTION 2. The commission is authorized to devise projects and prepare plans and specifications thereof for the purpose of securing a greater use of the water power resources now wholly or partially within the control of private citizens or corporations, and after notice and a hearing may order such owners, or some of them, to carry out said plans, may determine by which of such owners the work of construction should be done, and may fix a reasonable time within which such work shall be begun and finished, as well as the dates for intermediate stages thereof. In the event that such orders are not complied with by the owners designated before the date fixed, the commission is authorized, with the approval of the governor and council, to take possession as receiver of the property of such owners, and to make or complete such development, and to operate the old and new properties until the net revenue thereof, after payment of operating cost, including such repairs, renewals and improvements as the commission shall adjudge advisable, shall reimburse the commonwealth for the expense of such development, with interest at the rate of five per cent per annum.

SECTION 3. The commission is further authorized, after notice and a hearing, to provide for and require co-ordination and co-operation between power-producing or power-distributing plants, or both, and the owners thereof wherever water power as it is now developed or as it may be developed can be made of ad-

vantage to the users of power within the commonwealth, and in case the owners cannot agree as to the terms and conditions thereof, the commission shall have power, after due hearing, to determine and prescribe the same.

SECTION 4. The commission is authorized, after notice and public hearing, subject to the approval of the governor and council, to take by right of eminent domain any undeveloped water resources and any land or other property which it may determine to be necessary for the complete utilization of the flow of any river within the bounds of the commonwealth. The commission shall have power, with the approval of the governor and council, to lease under such covenants and conditions as they may prescribe any land or property taken under the provisions of the foregoing sentence.

SECTION 5. The commission may co-operate with officials and boards of the commonwealth, officials, boards and commissions of the United States or any neighboring state where rivers and water resources exist in any way connected with or capable of co-ordination with those furnishing power to industries within the commonwealth of Massachusetts, and may act jointly with such officials, boards or commissions in utilizing and conserving water resources. It may be represented at any hearings before any legislative committee or public board of this commonwealth or of the United States or of any adjoining state with respect to any proposed legislation or action by public authorities within or without the commonwealth, affecting any water resources within the commonwealth, whenever in its opinion such representation is desirable in the interest of the commonwealth.

SECTION 6. The powers granted by sections two and three hereof may be exercised either independently of each other or in one and the same proceeding. The supreme judicial court shall have jurisdiction in equity to enjoin the execution or enforcement of any order of the commission made under the provisions of this act which is unlawful, to the extent of such unlawfulness, and shall further have jurisdiction in equity upon the application of the commission to enforce all valid orders thereof.

SECTION 7. For the purposes of carrying out the provisions of this act there is appropriated out of the treasury of the commonwealth the sum of _____ dollars, in addition to any unexpended balance remaining out of the appropriation provided under chapter one hundred and thirteen of the resolves of nineteen hundred and fifteen.

REPORT OF THE ENGINEER.

To the Commission on Waterways and Public Lands, State House, Boston.

GENTLEMEN: — I beg to submit the following report on the water conservation investigation, which for convenience has been divided into three parts, as follows: —

- I. RÉSUMÉ.
- II. PRECIPITATION AND RUN-OFF.
- III. DESCRIPTIONS OF WATERSHEDS AND STORAGE INVESTIGATIONS.

PART I.

RÉSUMÉ.

This investigation of the water resources of the Commonwealth of Massachusetts is doubtless a reflection of the sentiment and feeling prevalent throughout the country during the last ten or fifteen years, that more definite knowledge should be gained of the extent and use of the water resources of the country and the possibilities of their further conservation. Do they constitute a much-neglected natural resource, or have they been and are they being utilized about as much as circumstances warrant?

The direct cause of the investigation was the attempt during the winter of 1912-13, by the Millers River Improvement Company, to obtain a charter for the purpose of building a system of storage reservoirs on the Millers River, which flows from Winchendon through Athol and Orange, and enters the Connecticut River at Erving, just above the power development of the Turners Falls Power Company. On account of certain privileges sought by the Improvement Company, the

bill did not meet with the general approval of the users of water power in the State, and it was finally rejected by the General Court. The question was raised that if this charter were granted on the Millers River it would lead to similar privileges being sought on other streams of the Commonwealth. It was maintained that the adoption of such a policy might have unforeseen consequences, and therefore, before granting such legislation, it seemed desirable to view the State as a whole, and consider all of the water resources rather than any one particular stream.

As a result the General Court, by chapter 129 of the Resolves of 1913, created a Water Conservation Commission, consisting of the chairman of the Board of Harbor and Land Commissioners, the chairman of the Gas and Electric Light Commission, and the Attorney-General, and directed it to make a general survey of the entire State and report "what legislation, if any, is expedient or advisable to better conserve the waters and provide for the utilization and equalization of the flow thereof in the rivers and natural streams of the Commonwealth." An appropriation of \$5,000 was made for the purpose. This commission reported in writing to the General Court of 1914 (see House Document No. 1063), recommending a "complete and comprehensive investigation of all our water resources to secure the proper basis for a report for the utilization of this valuable and neglected asset of the Commonwealth." Upon the recommendation of this commission the General Court, by chapter 95 of the Resolves of 1914, directed the Board of Harbor and Land Commissioners to undertake this investigation, and to expend for the same a sum not exceeding \$5,000; but as the funds were inadequate the work was not commenced until a further appropriation was made under the act quoted on the first page of the report by the Commission.

The investigation has comprised —

1. An inventory of the amount and location of the potential water power of the State.
2. An inventory of the existing water-power developments.
3. An examination of the undeveloped stretches of the rivers.
4. An inquiry into the uses of the various lakes and ponds.
5. An investigation of possible storage reservoir sites.

While this report is confined to the rivers and streams in Massachusetts, considerable information relating to the upper reaches of these rivers that are outside of the State has incidentally been obtained and placed on file.

Accompanying the report is a map of the State showing the areas drained by the various rivers and the location of the developed and undeveloped water powers. Profiles are shown of eleven of the most important streams, and there are watershed maps of the Millers and Westfield rivers, showing the location of the proposed reservoirs.

In Appendix I. there is given a list of the lakes and ponds of the State with their areas, as determined from the best sources available. The first published list of the lakes and ponds of the State was prepared by F. H. Walling, and printed in the report of the State Board of Health for the year 1873. This list, with corrections for certain lakes which had been surveyed by the Board of Harbor and Land Commissioners, was republished in the report of that Board for the year 1913. The present table is a complete revision of the Walling list. The results of definite surveys have been given wherever possible; in other cases the areas have been carefully determined from the original plane table sheets of the topographical survey of the State, made by the United States Geological Survey in co-operation with the Commonwealth of Massachusetts. These original sheets are on a scale of 1:30,000, which indicates, in connection with the nature of the survey, that the areas of the lakes and ponds as thus determined can only be considered as approximate; but while actual surveys have not been made of a large number of the lakes, the list as thus revised is much more accurate than those previously published.

POTENTIAL WATER POWER.

What is the total potential water power of the State is the first question which naturally arises in considering this subject. The most comprehensive estimates of the potential water power of the country were made by the United States Geological Survey for the Conservation Congress in 1908, and were expressed in terms of the minimum and maximum horsepower. The minimum estimates represented the amount of power that could be developed from the use of the flow for the lowest two consecutive seven-day periods in the year. The maximum represented the amount that could be developed from the use of the average maximum continuous stream flow available for six months during the year. The original estimates of the survey were based on a development of 90 per cent. of the fall, with a further reduction of 10 per cent. to allow for inefficiency of water wheels. The flatter portions of river channels, which can obviously never be profitably developed for power, were excluded.

The estimate for minimum horsepower was doubtless designed to represent the total primary water power of the country or power available at all times. The estimate of the maximum horsepower was apparently intended to represent the maximum wheel installation to be expected, based on the assumption that it was good financial practice to develop an installation up to that amount which is assured during six months of the year.

Omitting storage from consideration, and excluding Pennsylvania, for which State figures were not available at the time of the report, but including a portion of the Rio Grande in Mexico and certain drainage areas in Canada, the final estimates gave a minimum of 36,916,250 horsepower and a maximum of 66,518,500 horsepower.

The Geological Survey's estimates were reviewed and corrected by the Commissioner of Corporations in 1913, in a report on "Water Power Development in the United States," the totals for the potential water-power resources being reduced to 27,943,000 horsepower for the minimum, and 53,905,000 horsepower for the maximum. In these new estimates a water-

wheel efficiency of 75 per cent. was assumed. The minimum and maximum potential horsepower for the State of Massachusetts as thus estimated by the Commissioner of Corporations amounted to 118,000 and 228,000 horsepower, respectively.

A summary of these estimates is contained in the report, "Electric Power Development in the United States,"¹ made by the secretary of Agriculture to the United States Senate in 1916.

For the purposes of this investigation it was desired to make an estimate of the total potential water power of the State, based on the mean annual run-off rather than on the assumptions used by the Geological Survey. The total potential power is the equivalent of the total energy resulting from the fall of the total yearly flow through whatever head or fall may be available on the watershed in question. This flow is never uniformly distributed; in the spring it reaches flood proportions, while during certain periods of the summer it may fall below 10 per cent. of the average yearly flow. However, the total potential energy of the water for the year is the same regardless of its distribution. Estimates for this figure have been made for the entire State and expressed in wheel horsepower on the basis of 80 per cent. efficiency, for convenience of comparison with actual installed power. The method adopted has been to assume from the available data an average mean annual run-off in second-feet per square mile of drainage area for each stream, and, by dividing the river into sections, to obtain for each section its potential power by combining the estimated unit flow and gross fall with the drainage area at the upper end of the section. This result is then reduced by 20 per cent. to allow for the loss in conversion into power by water wheels. The result gives the total potential energy of the water of any stream at 80 per cent. efficiency, and may be considered either as horsepower generated continuously twenty-four hours a day throughout the year, or as horsepower years.

Estimates have thus been made for all the main streams and their more important tributaries, excluding non-contributing areas and in general those tributaries whose drainage area falls below approximately 10 square miles. The total potential

¹ Document 316, 64th Congress, 1st Session.

water power of the State as thus estimated amounts to 506,593 horsepower generated continuously twenty-four hours a day. Its distribution among the various streams is shown by Table I. on page 12. This figure represents the theoretical maximum, and is of course greatly in excess of any practicable utilization. It is reduced by (1) the unequal flow of the streams; (2) the impossibility of developing certain portions of the rivers, due to their slight declivity, and other factors producing an excessively high cost of development; (3) the lack of continuous operation on the developed sites, which allows the water to waste during the non-working hours.

To avoid confusion in comparing potential horsepower with the horsepower of installed water wheels, it should be kept in mind that the potential power of a stream computed upon a continuous operation of twenty-four hours a day also represents the total wheel power for the same period of operation. If, however, there is pondage sufficient to store one-half the flow, then twice the wheel power developed in twenty-four hours can be operated during twelve hours, and theoretically the maximum wheel power for twelve hours' operation with complete pondage becomes, in round numbers, 1,000,000 horsepower for the total potential energy of the State, at 80 per cent. efficiency. Therefore it is possible, with adequate pondage, for the installed capacity of water wheels to be in excess of the potential power of the stream.

POTENTIAL POWER OF DEVELOPED HEADS.

The figure given above represents the total potential water power of the State as determined from estimated flows through given falls. An estimate of this potential energy has been made for each stream by combining the same mean run-off that was used in the preceding estimate with the drainage area and gross fall at the developed sites. This figure represents the amount of energy which could be developed from the existing water powers of the State, assuming that it is possible to make use of the total run-off and neglecting friction losses. It shows what proportion of the fall which gives rise to the total potential water power of the State has been developed. The total figure thus obtained amounts to 333,811 horsepower, and its

distribution among the various streams is also shown in Table I., page 12. As previously explained, this figure must not be confused with the installed capacity of water wheels or the power actually generated; for example, assuming that a water-power site on a stream having a mean flow of 100 second-feet with a net head of 20 feet is developed at a uniform rate throughout the year, it would yield 182 horsepower at 80 per cent. efficiency. A manufacturer might, however, develop this power with a wheel capacity considerably more or less than the capacity required to develop this mean flow. Therefore the wheel capacity of an installation may indicate only in a general way the potential power of the site.

TABLE I. — *Water Power of Massachusetts.*

NAME OF RIVER. 1	Assumed Mean Rate of Flow (Second-feet per Square Mile). 2	Maximum Potential Horsepower for Assumed Rates of Flow. 3	Potential Horsepower of Heads for As- sumed Rates of Flow. 4	INSTALLED CAPACITY OF WATER WHEELS.			Potential Horsepower of Undeveloped Sites for As- sumed Rates of Flow. 8
				Twenty-four Hour Power. 5	Eight to Ten Hour Power. 6	Total. 7	
Merrimack.	1.48	52,200	41,400	5,630	49,848	55,478	-
Connecticut.	1.70	162,000	148,500	91,588	12,611	104,199 ¹	-
Millers.	1.67	31,000	11,800	4,750	4,449	9,199	14,850
Deerfield.	2.35	83,700	40,200	55,500	1,412	56,912	30,400
Chicopee.	1.50	42,800	30,200	7,920	28,446	36,366	5,480
Westfield.	2.00	61,500	14,646	6,615	1,229	7,844	31,000
Farmington.	1.90	6,750	713	-	238	238	5,500
Housatonic.	1.85	19,050	12,100	7,274	4,346	11,620	-
Hocusec.	1.88	6,710	4,100	290	3,738	4,018	-
Quinebaug.	1.50	4,570	2,940	220	3,950	4,180	360
French.	1.50	1,970	1,430	-	3,168	3,168	-
Blackstone.	1.50	7,990	6,200	-	9,980	9,980	-
Nashua.	1.66	10,500	7,860	9,192	1,737	10,919	-
Concord.	1.53	4,591	3,728	277	3,359	3,636	-
Shawheen.	1.55	687	363	-	610	610	-
Powow.	1.58	750	571	2,070	-	2,070	-
Spicket.	1.58	1,050	740	-	730	730	-
Jewich.	1.58	835	550	-	200	200	-
Charles.	1.55	3,040	2,130	220	1,010	1,220	-
Neposset.	1.50	1,810	1,490	100	635	1,035	-
Taunton.	1.60	2,400	1,960	650	1,080	1,730	-
Totals.		506,593	333,811	192,286	133,096	325,382	87,590

¹ Provision has been made at Turners Falls for the installation of two additional units of 10,000 horsepower each, which will increase this figure to 124,199.

As an illustration, the Connecticut River at an assumed mean flow of 1.7 second-feet per square mile develops a maximum potential energy of 162,000 horsepower, of which the developed heads represent 148,500 potential horsepower; but the capacity of the installed water wheels on an eight, ten and twenty-four hour operation is 104,199 horsepower.

The installed capacity of water wheels will be again considered.

UNDEVELOPED WATER POWER.

As shown above, 66 per cent. of the fall which gives rise to the potential water power of the State has been developed while heads representing 172,782 potential horsepower remain undeveloped. For various reasons — such as the slight slope of some portions of the streams, small heads between existing power developments which neither the privilege above nor the one below can make use of, and the small amount of power available in many of the smaller tributaries — a large part of this undeveloped water power must be considered as unavailable.

There are certain stretches of streams within the State with a considerable fall, whose development depends primarily upon the cost of the power obtained being less than the cost of generating an equal amount of steam power. An estimate has been made of the potential power of the larger and more important undeveloped stretches which can be considered as possible for commercial use at a reasonable price for power. It may be that some of these privileges could be profitably developed at the present time, while others would undoubtedly require a very great increase in the value of power before their potential energy could be made use of. In the preparation of this estimate only the larger and more important water powers have been considered; those of less than 250 horsepower have not been included because there is no market at present for these small isolated power sites. There are innumerable small privileges of from 50 to 200 horsepower that could be developed by any one in a position to make use of them.

The same rates of flow have been used as in the previous estimates, but the flows have been combined with the drainage area and 90 per cent. of the gross head to allow for stretches of

river whose development might prove undesirable, and an 80 per cent. factor of efficiency has been applied to the water wheels. The total figure for the State as thus obtained, including the two additional units of 10,000 horsepower each, for which room has been provided at the Turners Falls development on the Connecticut River, amounts to 87,590 horsepower. This figure is directly comparable with the 333,811 potential horsepower of developed heads and 506,593 horsepower of total potential water power of the State.

INSTALLED CAPACITY OF WATER WHEELS.

The total capacity of water wheels installed within the Commonwealth is 325,382 horsepower, as shown by the inventory of the various streams in Table I., page 12. This installation of 325,382 horsepower occurs at sites whose potential energy amounts to 333,811 horsepower, as found by the previous estimate, and given in the same table. Therefore, the installed wheel capacity for the State as a whole is about equal to the power representing the mean annual flow of the developed heads of the streams. In considering this relation it should be borne in mind that the estimates of potential power of developed sites have been made on the basis of gross head rather than net head.

Assuming that for the State as a whole the net head of the power development equals 90 per cent. of the gross head, then, if the total potential energy at these developed water-power sites could be used, the result would be equivalent to a continuous output of 90 per cent. of 333,811 horsepower, or 300,000 horsepower years. The actual output is very much less than this figure, but an attempt that was made to carefully estimate the amount for the entire State was abandoned owing to the difficulty of obtaining the necessary information, and instead a careful estimate has been made for a number of selected cases. These estimates indicate that, taking the State as a whole, the actual output varies between 25 and 40 per cent. of the total potential power at the developed sites. The range varies from some of the small power developments, where wheels are used simply to obtain a small amount of power at odd times during the year, to the development by the New

England Power Company on the Deerfield River, where a large installation of wheels is in operation almost continuously whenever there is water available.

A conservative estimate would probably place the actual water-power output at 33 per cent. of the total power available at the developed sites, which, if reduced 10 per cent. to allow for the difference between gross head and net head, indicates an output of 100,000 horsepower years. The two principal reasons for this figure being so much below the maximum possibilities at the power sites are, first, the unequal flow of the streams; second, lack of continuous operation of the power plants. In many cases the wheels operate only from eight to ten hours daily for six days a week. Where pondage is available a part of the flow which takes place during the non-working hours can be saved, the amount depending on the volume of pondage.

If the waste in power due to the unequal flow is considered as that part of the run-off which takes place in excess of the mean flow, then, considering the State as a whole, the loss from this cause amounts to about 40 per cent. of the total, as shown by Table V., Part II, page 27.

Assuming that a given plant operates nine hours a day for six days a week, and that there is no pondage available, the loss which takes place during the hours when the plant is shut down would amount to 68 per cent. of the total in addition to that due to the unequal flow. However, as 192,286 horsepower of installed water-wheel capacity, which is nearly 60 per cent. of the total, is operated twenty-four hours a day, and as considerable pondage is in use throughout the State, the actual waste during the non-working hours of the day is considerably less than this figure. Nevertheless, the loss due to non-continuous operation is an important factor, and a careful study of all water-power plants should be made to ascertain if it can be reduced, because of the fact that certain hydro-electric developments furnishing energy to a large transmission system which acts as a clearing-house for power are known to possess a marked advantage in the more complete use of the water power over manufacturing establishments operating only eight to ten hours a day.

TOTAL POWER OF ALL KINDS IN USE.

It is also of interest to know the relation of water power to the total power of all kinds in use. The total capacity of all prime movers used in manufacturing industries, central stations and electric railway power stations in this State amounts to about 2,200,000 horsepower, as shown by the following table:—

TABLE II. — *Total Power in Massachusetts.*
[Installed capacity.]

	Horsepower of Prime Movers.	Source of Information.	Date of Information.
Manufacturing plants, . . .	1,393,722	1915 census of manufacturers,	June 1, 1915
Central stations, . . .	532,682	1915 report of Gas and Electric Light Commissioners.	June 30, 1915
Street and electric railways, .	255,500	Public Service Commission, .	June 30, 1914
Total, ...	2,184,854		

This includes steam engines, turbines, water wheels, and gas and gasoline engines, but does not include locomotives used on railroads. These figures, broadly speaking, are for about the year 1915. The figures for the water-wheel installations are mostly for the year 1916, although it is not thought that the total installed capacity of water wheels has varied much during the three years 1915, 1916 and 1917, except for the redevelopment at Turners Falls. The capacity of the steam stations has doubtless increased substantially since 1915. It is thus seen that in 1915 the installed capacity of water wheels amounted to about one-seventh of the total capacity of all prime movers in the State, but it is impossible to say whether the load factor of the steam and gas plants is higher or lower than that for the water wheels, although it is probably not far different.

STORAGE.

As explained in the introduction to the detailed report, the Millers, Westfield and Farmington rivers are the only streams in the State where the conditions appeared favorable for the creation of a system of storage reservoirs for producing more

evenly distributed flow throughout the year. Preliminary investigations have been made of the possibilities on these three streams, which include a review of work previously done by private parties, together with additional surveys by the engineers of the commission.

The reservoir investigations have necessarily been of a preliminary nature, and this fact, together with the unsettled prices and conditions arising from the war, has made it impossible to prepare estimates of the cost that are sufficiently accurate to determine the precise value of the benefits that will result from the building of the proposed systems of reservoirs. Moreover, the problem is complicated by the close relation between the proposed reservoirs and the undeveloped power. However, estimates have been made from the information available, based roughly on the prices existing before the war, which will indicate in a general way the desirability of the projects.

On the Millers River it appears that a system of eight reservoirs can be built storing a total of 6,413,000,000 cubic feet, with a power development of 800 kilowatts at one of the reservoir sites. The estimated cost of this system, including the power development, is \$2,276,384. On the Westfield River the desirable reservoir sites were finally reduced to three, with a combined storage capacity of 1,586,000,000 cubic feet. Two of these reservoir sites could also be utilized for developing power with an installed capacity of 8,000 horsepower of water wheels. The estimated cost of these three projects, including power developments, is \$1,680,000.

On the Farmington River the conditions are quite different because the market for the power appears to be in the State of Connecticut; but two reservoir sites were surveyed with a maximum storage capacity of 2,032,000,000 cubic feet.

As shown in the detailed discussion of the storage situation on the Millers and Westfield rivers, it is doubtful if in either case the system of reservoirs could be profitably built for the benefit of the existing water-power development. However, there is a considerable amount of undeveloped water power on these rivers, but the development of this power is closely linked with the question of additional storage. The water power

would be greatly benefited by the additional storage, while the latter requires the additional fall. The two problems cannot be separated.

The greater part of the undeveloped fall of these streams is owned by private companies, and if the plans they have prepared for their development could be carried out there is little doubt but that a part and perhaps all of the proposed reservoirs could be profitably built. If, however, this storage is to be created by private capital it will probably require the cooperation of all the parties who will benefit therefrom; but the projects are so large and so many interests are affected that it is doubtful if it can be accomplished by a voluntary organization of the mills similar to those joint efforts which have brought about the construction of numerous small reservoirs on various streams throughout the State. Either State supervision of reservoir companies, or possibly even State construction of reservoirs, may prove desirable, and in any event it may be necessary to invoke the right of eminent domain to accomplish the desired result. The financial support of the State may also be necessary, and would undoubtedly be of great value to the projects.

The advantages arising from the proposed systems of reservoirs would be —

1. An improvement of the existing privileges.
2. The development of the undeveloped stretches of the river, thus further utilizing the State's natural resources.
3. The equalization of the flow of these streams, which would increase their ability to overcome pollution during the summer months and make possible greater industrial development.
4. A lessening of floods, particularly on the Westfield River.

It is believed that these projects are of sufficient size and importance to warrant the attention of the State.

A detailed description of possible storage sites will be given in the following pages under the name of the river whose waters they will conserve.

It will be found that there are at least thirty-one reservoirs, on ten of the rivers which are enumerated below, of such feasibility that it is of interest to compute their power value to existing plants on these streams.

These thirty-one reservoirs will be capable of storing 21,582,000,000 cubic feet of water. If it is assumed that this is available only once a year it will add to 146 existing mill privileges 8,721 horsepower generated continuously twenty-four hours a day, or 26,958 horsepower on the basis of nine hours' operation each day.

The details of this statement are as follows: —

RIVER.	Number of Reser- voirs.	Storage (Million Cubic Feet).	HORSEPOWER.		Number of Mills ben- efited.
			Per Annum.	Nine Hours.	
Millers, ...	8	6,413	3,303	10,276	29
Chicopee, ...	3	1,870	2,610	8,117	46
Westfield, ...	4	2,479	1,367	4,268	12
Farmington, ...	2	1,099	300	933	3
Housatonic, ...	1	300	120	375	7
Nashua, ...	2	5,600	309	960	3
Shawsheen, ...	1	200	26	81	4
Charles, ...	3	1,325	311	782	11
Nepomset, ...	3	1,359	277	861	27
Taunton, ...	4	137	98	305	4
Totals, ...	31	21,582	8,721	26,958	146

PART II.

RAINFALL AND RUN-OFF IN MASSACHUSETTS.

RAINFALL.

The Commonwealth of Massachusetts is very fortunate in having a relatively large amount of data in regard to the rainfall and run-off throughout the State. The most complete collection of rainfall data is that made by Mr. X. N. Good-nough, chief engineer of the Massachusetts State Department of Health, published in the September, 1915, number of the Journal of the New England Water Works Association. The paper is entitled "Rainfall in New England," and is a compilation and revision of reliable rainfall records at a large number of stations throughout New England, covering a period from 1749 to 1913. The paper contains a map of New England showing lines of equal rainfall, and also a general discussion of precipitation from which the following is taken.

Taking the State as a whole the mean annual precipitation is in the neighborhood of 44 inches. This is exceeded in the Berkshire region, where, for a territory running north from Granville and Westfield, the precipitation exceeds 48 inches. On the west it gradually decreases to about 42 inches at the western border of the State, and also becomes less towards the Connecticut River, where there is a precipitation of about 45 inches in the southern part of the State, which is reduced to 40 inches as the New Hampshire line is approached. Moving east from the Connecticut River the precipitation increases to a mean average of 46 inches in the higher altitudes of the central part of the State northwest of Worcester, whereas along the northern boundary of the State east of the Connecticut River the precipitation is about 40 inches, increasing to the south to about 44 to 46 inches in the vicinity of Boston and Brockton, respectively. A still higher precipitation is recorded in the region of New Bedford, but proceeding along the Cape

the rainfall drops to about 40 inches for a line through Provincetown and Nantucket.

The yearly distribution of rain throughout the State is remarkably uniform. An examination of the rainfall records discloses the fact that March and August are the two high months of the year. In eastern Massachusetts, or more particularly southeastern Massachusetts, March is the high month, and the precipitation is greater during the winter and spring than in the summer and fall. On the other hand, in the western part of the State August is usually the high month, and the greater rainfall takes place during the month of March and the summer months, July, August and September, while December, January and February are the dryer months of the year.

RUN-OFF.

The percentage of rainfall which runs off in the streams is dependent upon a number of factors in addition to the amount of the precipitation. A much greater percentage of the rainfall runs off during the winter and spring, when the ground is frozen and saturated with water, than runs off during the summer months when the ground is dry and a much larger amount of water is absorbed or evaporated. The topography of the watershed also has a marked influence on the percentage of run-off. A flat swampy basin containing a large proportion of cultivated land naturally retains more water than a steep and rocky watershed which tends to shed the rain as it falls.

For the purpose of estimating the total potential water power of the State, and the proportion of it which has been developed, figures were required for the mean annual run-off of each of the principal rivers and streams. In making such estimates it should be recognized that at best only an approximation can be obtained. In the first place, only a limited amount of actual run-off data is available, and, in the second place, it must be realized that from the technical standpoint it is difficult to say exactly what is meant by the mean annual run-off of a watershed. Generally speaking, the rate of run-off per square mile increases as one goes from the mouth to the source of a stream, and as a result there can hardly be said to be a constant rate for any two places on the watershed. Therefore in this report

an attempt has been made to estimate the mean annual rate of run-off for a central portion of the basin, and this has been used for the entire watershed.

The only method of predicting future run-off is to base the estimates upon records obtained in the past. The Commonwealth of Massachusetts has co-operated with the United States Geological Survey to obtain such records, which, together with a considerable amount of additional data furnished by private companies, is contained in the United States Geological Survey's Water Supply Paper 415, entitled "Surface Waters of Massachusetts." This constitutes a collection of run-off data for the State similar to the paper on rainfall by Mr. Good-nough. Water Supply Paper 415 includes records up to Oct. 1, 1915, and data obtained since have been furnished by the United States Geological Survey which is published as Appendix II. of this report. These records form the base data from which the estimates used in this report have been made.

Definite long-term records are available for the Merrimack River at Lawrence for thirty-seven years; the Sudbury River, a tributary of the Concord, for forty-one years; the Connecticut River at Orford, N. H., for seventeen years; and the South Branch of the Nashua River at Clinton for twenty years. Shorter-term records varying from two to ten years are available for the Millers, Deerfield, Westfield, Housatonic, Farmington, Swift, Ware and Quaboag, the last three being tributaries of the Chicopee River.

On the streams for which short-term records only are available the method pursued has been to compare the run-off, during the same years, with those of streams for which long-term records have been obtained, and then to adjust the short-term records in accordance with this ratio. When applying the ratio between short and long term records for the Merrimack, Sudbury, Nashua and Connecticut rivers certain discrepancies arise due to the varying rates of the flow of these streams, and it has been necessary to make an arbitrary adjustment. A study of the long-term records shows that, in general, short-term records of flow covering the last eight to ten years must be increased to arrive at the probable mean flow to be expected over a long period of time.

Table No. III., on page 24, shows the streams for which records are available, the duration of such records, and the estimates made for the mean annual run-off. For the remaining streams of the State it has been necessary to make estimates based on an analogy with the adjoining basins, although records obtained by the State Department of Health have been of assistance in making estimates for the Neponset and Ipswich rivers. The estimates made for all the streams of the State are shown in column 2 of Table I., Part I.

TABLE III. — Summary of Stream-gauging Records in Massachusetts.

RIVER.	Location of Gauging Station.	Drainage Area at Gauging Station (Square Miles).	Period of Gaugings.	Number of Years of Gaugings.	Mean Flow during Period (Second-feet per Square Mile).	Estimated Mean Run-off from Watershed (Second-feet per Square Mile).
Merrimeck.	Lawrence.	4,452 ¹	1879-1916	37	1.48	1.48
South Branch, Nashua.	Clinton.	118 ²	1896-1916	20	1.66	1.66
Sudbury (Concord River).	near Framingham.	175	1875-1916	41	1.53	1.53
Connecticut.	Orford, N. H.	3,100	1900-1917	17	1.74	1.70
Connecticut.	Sunderland.	8,000	1905-1917	12	1.66	1.66
Deerfield.	Shelburne Falls.	500	1907-1917	10	2.22	2.35
Millers.	Charlestown.	333	1914-1917	3	1.68	1.67
Chicopee.	Erving.	372	1912-1917	5	-	1.50
Ware River.	Gibbs Crossing.	201	1912-1917	5	-	1.50
Swift River.	West Ware.	136	1912-1917	5	-	1.50
Quabog River.	West Brimfield.	150	1912-1917	5	-	1.50
Westfield.	Westfield.	498	1914-1917	3	1.72	2.00
East Branch.	Knightsville.	162	1909-1917	8	1.80	2.00
Middle Branch.	Great Heights.	153	1910-1917	7	1.96	1.85
Housatonic.	Great Barrington.	280	1913-1917	4	1.75	1.85
Farmington.	New Boston.	93	1913-1917	4	-	1.90

¹ Net drainage area.² The area of the basin changed at times in connection with changes in the water supply systems of the metropolitan district. From 1896 to 1907, 119 square miles; 1908 to 1913, 118.19 square miles; 1914 to 1916, 108.84 square miles.

Considering the State as a whole, it will be seen that east of the Connecticut River the estimated run-off varies from about 1.4 to 1.7 second-feet per square mile, while west of the Connecticut a much larger run-off obtains, rising to 2 second-feet per square mile for the Westfield River, and 2.35 second-feet per square mile for the Deerfield. The latter is very high, but it seems to be warranted by the actual records for the last ten years, which has been a period of less than average run-off. For the Connecticut River, situated between these two regions, an estimate of 1.7 second-feet per square mile has been made.

The data for the Connecticut River are somewhat contradictory. Records taken at Holyoke for the twenty-year period from 1879 to 1899 showed an average run-off of 1.43 second-feet per square mile, while records taken by the United States Geological Survey at Orford, N. H., from 1900 to 1917, show a run-off of 1.74 second-feet per square mile for that period, and records kept at Sunderland, Mass., 18 miles above Holyoke, for the last twelve years show a run-off of 1.66 second-feet per square mile, which is a lower rate of run-off than would be expected over such a long period. The drainage area at Holyoke is more than double that at Orford, from which a lower rate of run-off would naturally be expected at Holyoke were it not for the fact that the Connecticut is joined between these two points by the Deerfield and the Millers, the latter having a run-off of about 1.67 second-feet per square mile, while the Deerfield gives its high estimated rate of 2.35 second-feet per square mile.

Considering these factors it is believed that the later records should be given the greater weight, and therefore the figure assumed of 1.7 second-feet per square mile is not too high for the mean run-off of the Connecticut River at Holyoke.

DISTRIBUTION OF RUN-OFF.

The monthly distribution of the run-off is an important question. It is a matter of common observance that streams are much swollen during the spring months, and it is important to know what proportion of the run-off takes place at such times. Table IV. (on page 26) shows the percentage of the run-off which has taken place during the several months of the year at various gauging stations in the State.

TABLE IV. — *Percentage of Run-off occurring during Each Month at Various Gauging Stations in Massachusetts.*

MONTH.	Merrimack at Lawrence, 1880-1914 (35 Years).	South Branch of Nashua at Clinton, 1897-1916 (20 Years).	Sudbury Watershed, 1875- 1916 (42 Years).	Connecticut at Sunderland, 1906-17 (12 Years).	Deerfield at Shelburne Falls, 1906-13 and at Charle- mont, 1914-17 (10 Years).	Swift at West Ware, 1913-17 (5 Years).	Quabog at West Brimfield, 1913-17 (5 Years).	Westfield at Knightville, 1910-17 (8 Years).	Middle Branch of Westfield at Cross Heights, 1911-17 (7 Years).
January, ...	7.4	9.4	10.2	7.3	8.6	9.1	11.2	11.3	11.1
February, ...	8.0	10.2	13.2	5.8	6.6	8.4	8.8	7.6	7.9
March, ...	15.7	20.2	23.3	12.3	14.0	16.8	18.0	18.7	17.6
April, ...	20.9	16.7	16.7	24.1	25.6	19.7	20.3	21.9	23.0
May, ...	12.3	9.5	9.2	15.0	11.7	11.4	11.3	9.3	9.3
June, ...	6.7	5.9	4.0	7.9	5.6	6.8	6.5	6.2	4.6
July, ...	3.9	3.5	1.6	4.2	3.8	6.0	4.8	3.1	2.3
August, ...	3.6	3.5	2.1	3.6	3.1	5.9	4.8	2.9	2.2
September, ...	3.6	2.5	1.8	2.7	2.3	3.2	2.8	1.9	1.3
October, ...	4.6	3.9	3.5	5.0	5.8	3.1	2.8	4.2	5.4
November, ...	6.4	5.6	6.1	5.6	7.0	3.6	3.4	6.1	6.9
December, ...	6.9	9.1	8.3	6.5	5.9	6.0	5.3	6.8	8.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

A study of this table shows that for the State as a whole between 20 and 25 per cent. of the yearly flow takes place during the month of maximum run-off, which is either March or April, depending upon the location and altitude of the basin, while 50 per cent. takes place during the three months of greatest run-off. These three months are February, March and April for the Nashua and Sudbury rivers, but March, April and May for the remaining streams of the table. In other words, the flow during the maximum month is nearly three times the normal for the year, while during the three months of greatest flow the average run-off is double that for the remainder of the year. The minimum month of the year is September, when the flow of all the streams given in the table falls to between 1.3 and 3.6 per cent. of the total, which is between 15 and 43 per cent. of the mean annual rate.

It is obvious that averaging the monthly flows tends to reduce

the effects of the uneven distribution of flow. It combines months of higher run-off in certain years with lower run-off in other years to give a more uniform average, and neglects the freshets which take place during the nine months other than March, April and May.

The most accurate results are obtained by grouping all the high flows together, as is done in "duration" or "time-flow curves," which are largely used in hydraulic practice. These curves are made by plotting the rate of flow opposite the percentage of time during which they are available, to form a curve, as shown under Millers River and Westfield River. This results in collecting all the high flows at one side of the chart, and all the low flows at the opposite side, with the intermediate flows grouped in between. If, now, a line is drawn on such a chart representing the mean flow of the stream, then the area above this line will represent the excess flow, or flow which takes place at a rate greater than the mean run-off. Estimates have been made for the following streams for the years of record stated, to show the amount of this excess flow, which has been found to be as follows:—

TABLE V. — *Percentage of Excess¹ Run-off.*

RIVER.	Location of Gauging Station.	Drainage Area at Gauging Station.	Period of Gauging.	Ratio of "Excess Flow" to Total Run-off (Per Cent.).
Merrimack, ...	Lawrence, ...	4,452 ²	1880-1915	34.75
Connecticut, ...	Orford, N. H., ...	3,100	1901-1915	39.40
Housatonic, ...	Falls Village, Conn., ...	644	1913-1915	38.90
Deerfield, ...	Shelburne Falls, ...	500	1908-1915	44.30
Westfield (East Branch), ...	Knightville, ...	162	1910-1915	46.40
Quabog, ...	West Brimfield, ...	150	1913-1915	37.70
Westfield (Main Branch), ...	Goss Heights, ...	52	1911-1915	48.90

¹ By excess run-off is meant that part of the run-off which takes place at a rate exceeding the mean flow for the period considered or the area of a "time-flow" curve above the mean flow line.

² Net drainage area.

It will be observed from the above table that the ratio which this excess flow bears to the entire run-off varies from 34.75 per cent. for the Merrimack River to 48.9 per cent. for the main branch of the Westfield River. About 40 per cent. would appear to be a good average for the State as a whole.

LARGER CAPACITY OF WATER WHEELS.

There are two methods by which a larger proportion of the run-off can be made available. The first is to produce a more uniform flow by means of storage reservoirs; the second is to secure the same result by the installation of a larger capacity of water wheels. If a distribution of run-off similar to that of the Westfield River at Knightville is taken for an example, and water wheels are installed having a capacity equal to that of the mean flow of the stream, they would develop 54 per cent. of the total run-off if run continuously to full capacity whenever the water is available. If, however, the installation of water wheels is increased to a point equivalent to double the mean flow of the stream, the additional power which could be developed during the spring months would amount to 20 per cent. of the total flow, or, in other words, double the capacity of wheels would increase the output 37 per cent. By sufficiently increasing the size of the installation a point would finally be reached where the entire flow could be utilized if the back-water conditions were neglected, but such a state of affairs would never be economical, for the larger the installation the more expensive it becomes, and a point will be reached where the interest and maintenance charges will amount to more than the value of the additional power obtained.

The tendency among the early power developments in the State was towards very low capacity of installation. In general, the manufacturing plants were entirely dependent upon water for power, and the size of the business and the capacity of the water wheels were limited to such a capacity as could be obtained for the greater part of the year. However, as the use of steam power increased to meet the demand for more power the practice developed in many if not the majority of the older plants of placing their main reliance upon power developed from coal, and to use the water power, whenever available, to save coal. As a result the tendency in water-power developments during recent years has been towards larger and larger installations which are able to use a greater and greater proportion of the flow, even without additional storage. This is particularly true of the hydro-electric developments operating large transmission systems which act as a clearing-house for

power. Such systems are in a position to use power at almost all hours of the day, and, by means of the installation of a large capacity of water wheels and continuous operation whenever water is available, are able to make a very complete and efficient use of the potential power of the streams.

PONDAGE.

Notwithstanding the apparent success of these large power plants, conservation by increased pondage is a matter requiring the most careful consideration in the economical use of water power, and is of the greatest importance to manufacturing establishments operating fifty-four hours a week, or from eight to ten hours a day. The actual hours of operation at fifty-four hours a week amounts to only 32 per cent. of the total time, which means that unless pondage is available to hold back the flow during the non-working hours, 68 per cent. of water is wasted. On the larger streams and more important developments of the State this question is given a great deal of attention, particularly on the Merrimack River and at the developments of the New England Power Company on the Deerfield River, as well as at the hydro-electric development on the Connecticut River at Turners Falls. On the other smaller streams, however, it appears that the users of water power do not generally appreciate the extreme importance of this question of pondage.

It must also be realized that developments on any river in close proximity to each other are interdependent as regards this question. If two plants are situated sufficiently close and operate during the same hours, then the lower privilege obtains the full benefit of the pondage at the upper development. However, a situation can easily arise whereby the distance between the plants and the hours of operation are such that a directly opposite effect is produced, and the pondage at the upper plant causes a waste of water at the lower plant. A careful study of the situation and co-operation among all concerned are required to produce the best results, which appear particularly necessary on the Millers, Chicopee, Westfield and Housatonic rivers, where it is possible to effect a considerable saving by an intelligent conservation of the flow of these rivers.

PART III.

DESCRIPTIONS OF WATERSHEDS AND STORAGE INVESTIGATIONS.

For the purpose of this investigation the main rivers and their important tributaries have been considered as separate streams, and as such they can be roughly grouped in four main divisions, as follows:—

1. Merrimack and Connecticut.
2. Connecticut River tributaries.
3. Border streams.
4. Eastern streams.

This division is based on area, location, slope, water power, population, etc. The dividing lines between the groups are not always definite, as there may be a gradual shading from the streams of one group to those of another, but it is sufficiently accurate for a general classification.

GROUP 1. MERRIMACK AND CONNECTICUT.

These are the two principal rivers of the State. The sources of both are in New Hampshire, and both flow across Massachusetts, the Merrimack to the Atlantic Ocean, and the Connecticut to Long Island Sound after crossing the State of Connecticut. Each has two important water-power developments within the boundaries of this State, — at Lawrence and Lowell on the Merrimack, and at Holyoke and Turners Falls on the Connecticut. At these four developments is installed very nearly one-half of the total water-wheel capacity of the State. There are no undeveloped stretches on either of these streams within this State. Both were originally developed at an early date as transportation routes, but the original canal companies were later changed over into power companies, although at the present time the renewal of navigation is proposed on both of

these streams. The main storage on these streams must be provided in the States of New Hampshire and Vermont, which has placed it outside of the scope of the present investigation. The more detailed reports are therefore confined to descriptions of the developments on these two rivers within the State of Massachusetts.

GROUP 2. CONNECTICUT RIVER TRIBUTARIES.

This group consists of the Millers, Deerfield, Chicopee, Westfield and Farmington rivers, which are the five main tributaries of the Connecticut in the State of Massachusetts, although the watershed of the Farmington is largely in the State of Connecticut. These are the most important water-power streams within the State next to the Merrimack and Connecticut. There is a total installed capacity within this State of 110,559 horsepower on these streams, which comprises one-third of the total water-wheel capacity of the State, or two-thirds of that remaining after the developments at Lawrence, Lowell, Holyoke and Turners Falls have been eliminated. These five streams also contain the greater part of the undeveloped water power, and also are the streams on which the conditions are most feasible for additional storage.

The Farmington River is different from the other streams in this group, in that while its water power was considerably developed and used in previous times, the lack of transportation facilities and changed manufacturing conditions have resulted in the closing of almost all of the mills, and its basin within this State is at present a thinly populated region.

GROUP 3. BORDER STREAMS.

This group includes the Housatonic, Hoosac, Quinebaug, French, Blackstone and Nashua. These streams all rise within the boundaries of this State and flow into adjoining States, but with the exception of the Nashua they reach their greatest importance for power development in the adjoining States. All were developed rather fully by small water-power privileges at an early date when water power was the only power, and in many cases the mills had to close down when there was a

shortage of water. On this account storage was developed to some extent on all these streams, in most cases by the co-operation of a number of the mills, which resulted in the occupation of the more favorable storage sites. Since their construction the population on the watersheds has increased, towns have grown up in the valleys, railroads have been built, and land values increased, so that in general the further storage of water for water-power purposes has become a costly problem.

All of the streams of this group are badly polluted, and a sufficient supply of pure water for manufacturing purposes is perhaps more necessary than additional storage for water power. In no case, however, is the amount of storage obtainable within a reasonable cost sufficient to prevent pollution by means of dilution. The prevention of pollution must be by means of purification of the manufacturing waste.

GROUP 4. EASTERN STREAMS.

This group includes the Concord, Shawsheen, Powow, Spicket, Ipswich, Charles, Neponset, Taunton, Acushnet, Weweantic, Quequechan and Mystic. These rivers, together with the Merrimack, drain the eastern part of Massachusetts. The areas of the watersheds are small and the slopes of the rivers flat. The developed water power on these streams is almost negligible except for the developments which in every case are found at the mouth of the river.

Since 1875, or possibly before, there have been numerous investigations of these rivers, but they have been concerned primarily with sources of water supply, sewage disposal, prevention of pollution by manufacturing waste, and the drainage of wet lands. The results are represented in the work of the Metropolitan Water and Sewerage Board, the creation of the Charles River Basin, the dredging of the Concord and Neponset rivers, and in other local improvements and various legislative acts for the prevention of the pollution of these streams.

The problem has been chiefly one of public health, and the general method of solution, outside of securing water supplies, has been that of drainage and purification rather than storage by reservoir building. The only case where reservoirs are now

suggested is on the Ipswich, and reference is made to the detailed description of this river for further information regarding the existing conditions.

STORAGE.

Leaving out the Merrimack and Connecticut, the streams on which the creation of storage reservoirs appears to be feasible at this time are the five Connecticut River tributaries of Group 2, and on only three of these — the Millers, Farmington and Westfield — was it deemed advisable to make a complete investigation on the part of the Commonwealth. The headwaters of the Deerfield are in Vermont, and additional storage reservoirs must be located in that State. Furthermore, by far the greater part of the power on this river is owned by one company, which is in a position to develop storage as required for the operation of its plants.

The development of storage on the Chicopee River is complicated by the possible requirements of the metropolitan system, which may ultimately take over the upper portions of the Ware River, and possibly of the Swift River. Furthermore, the companies on the Chicopee watershed that are most interested in the storage question have had investigations made of possible reservoir sites which would make any examination by the State a duplication of their work. As a result of these investigations the companies did not feel that storage could be created at a cost commensurate with the benefits at the present time, and the matter has been dropped by them.

It may also be said of the streams of Group 3 and Group 4 that while individual instances will continually arise where storage is required for public water supplies, and possibly for manufacturing purposes, there are no opportunities for the construction of one or more large reservoirs controlling the flow of the streams, with the exception of the Ipswich, where the possibilities have been investigated by the Salem-Beverly Water Board, which is described in the report on the Ipswich River. In all other cases the question of new storage reservoirs will depend upon the local conditions which may arise to make this storage necessary. Therefore it was decided that, as these could not be anticipated, no useful purpose would be served by a more complete investigation at this time.

Water stored in reservoirs and let down during the dry summer months may be useful in three ways, in addition to its requirement in connection with municipal water supplies: —

1. For developing water power.
2. For use in manufacturing processes.
3. For preventing disastrous floods.

A fourth use, that of irrigation, might also be added, but this use is bound to be somewhat limited in a State having a mean annual rainfall of over 40 inches fairly well distributed throughout the year.

If the question of cost is disregarded there is no reason why storage reservoirs could not be built at almost any place on any stream. However, when the cost is taken into consideration with the value of the benefits to be secured, the opportunities for storage reservoirs are considerably reduced in number. In the first place, the topography of a proposed reservoir site must be such that a dam of moderate height and moderate length will store a considerable volume of water. This means that there must be a closing in of the hills at the lower end of a relatively flat and open stretch of country. To store water in a steep and narrow valley means an excessive cost which cannot be justified commercially unless the value of the stored water is sufficient to pay for this high cost. Therefore the consideration of storage reservoirs is limited to places where nature has provided natural dam sites at the lower end of good reservoir sites.

The creation of storage reservoirs is also limited by the damage done by their construction, and if this means the relocation of railroads and highways, the flooding of good farming land, and the moving of villages and towns, the cost will be so high that it may preclude the building of storage reservoirs unless the storage is of the greatest importance.

The value of stored water for generating power depends primarily upon the head upon which it can be used, although size of water-wheel installations, loads, hours of operation, pondage and available market are also important factors that must have careful consideration.

The value of stored water for use in manufacturing proc-

esses such as washing, etc., also depends entirely upon the conditions existing on a given stream. If a large and important manufacturing district is built on a small watershed it may become necessary to obtain additional water for manufacturing processes to avoid limiting the expansion of the industries. However, in a State abounding in water resources, like the Commonwealth of Massachusetts, this aspect of the situation cannot be said to be at all serious, although local conditions may arise such as the situation in Fall River, where a large number of mills have been built on the Quequechan River, with a drainage area of only 27.5 square miles, a considerable part of whose flow is also required for the water supply of the city.

The volume of water required for strictly manufacturing purposes is small as compared with the amount required for water power, but the purification of the streams may be fully as important as that of an increased flow for manufacturing processes. Many of the smaller streams of the State are highly polluted, particularly during the low flow season of the summer. To prevent this pollution by dilution due to an increase in the flow of the rivers is not always feasible, and therefore the remedy may be by purification rather than by the building of storage reservoirs.

Fortunately the conditions in this State concerning floods are much more favorable than in some of the middle western States. The great damage due to floods on the Ohio and Mississippi rivers is primarily caused by the flat slope of the rivers which fails to carry off the water as fast as it accumulates, and this produces a great rise in the water level. In this part of the country the slope of the streams is much steeper, with the result that a given rate of run-off is very much less disastrous.

As for municipal water supplies, the direction of expansion of the main systems of the State has been largely determined by previous investigations. This question comes under the supervision of the State Department of Health, which has fully considered the needs of the various municipalities and the general methods of supplying them.

DETAILED DESCRIPTION OF RIVERS.

In describing the conditions on each river in the following pages there is first given a general description of the watershed, covering its location, area and general characteristics, as well as a brief statement of the larger areas appropriated for municipal water supplies. Following this is a brief discussion of the water power of the stream, the details of which are largely summarized in tables. A description of the principal undeveloped stretches of river follows, with estimates of the amount of undeveloped power, and a brief reference as to its availability. The storage situation is then taken up and a summary is made of the existing conditions, particularly as regards the existing lakes and ponds and the extent to which they are regulated for storage. This is followed by a discussion of the possibility of increasing the storage, with brief descriptions of the location and general features of the storage basins which have been examined, together with statements as to reasons for or against a further examination. The detailed information on the lakes and ponds is largely covered by tables.

A few words should perhaps be added regarding the character and reliability of the information which is given in the various tables. In the table covering the developed water powers there are columns giving the number of working hours, drainage area, head, horsepower of water wheels and area of pond, together with other information. No special effort has been made to determine the number of working hours with precision because the main question from the water-power standpoint is whether the mills operate only during the ordinary working hours of the day, or continuously night and day; therefore nine or ten hours have been used rather indiscriminately where the operation of the mills is not continuous.

The drainage areas at each privilege have been very carefully worked up from the topographical maps of the United States Geological Survey. The information regarding the developed heads and the installed horsepower of water wheels has been in most cases obtained from the owners of the privileges. At first it was hoped to give the head in two separate columns, one giving the gross and the other the average net head, but in few

instances could information sufficiently precise be obtained to make this feasible, and the only figure given is that for the average net head, which is liable to be 1 or 2 feet in error in many cases, as many of the mills, particularly the smaller ones, have not paid any particular attention to keeping precise statistics regarding their water power.

The figures for the capacity of the water wheels have also been obtained from the owners of the privileges. An attempt was made at the beginning of the investigation to obtain information regarding the make, type and size of the water wheels for the purpose of checking up the capacity stated by the mills, but it was found that this information could not be obtained in many cases, and that in general where it could be obtained it was at the larger water-power privileges where the most accurate information regarding rated horsepower could also be given.

The areas of the ponds within the basins above the dams have been measured from the best maps available. In a number of instances portions of the rivers have been surveyed by the Harbor and Land Commission in connection with the town boundary work, and in such cases the figures for the area of the pond should be accurate. In some of the other cases private surveys have been obtained, and these have been supplemented with measurements from the large scale plans in the county atlases which must be considered more or less approximate. The areas of the ponds are given for only the more important privileges on the rivers.

In the table of lakes and ponds on the watersheds only the principal bodies of water have been included; in general, those of 20 acres' area and over. The drainage areas have been carefully measured from the topographical maps, and the areas of the ponds themselves have been obtained from various sources. Where large scale plans or reliable local information could not be obtained the areas have been determined from measurements on the original plane table sheets of the topographical map, which are drawn on a scale of 1 to 30,000. The areas as given are more nearly correct than those given in any tables which have previously been published. Information regarding the amount of draft on reservoirs artificially controlled has been

obtained as far as possible from those who control the reservoir, and checked up by inspection in the field. In other cases it has been determined by measurements in the field, but there are doubtless instances where there are conditions not apparent which alter the amount of draft obtainable. Complete data for determining the storage capacity of the lakes used for storage purposes are not available, but estimates have been made from the best information at hand, although they must also be considered as approximate.

MERRIMACK RIVER.

The Merrimack, the second largest river passing through Massachusetts, is formed at Franklin, N. H., by the union of the Pemigewassett and Winnepesaukee rivers. From thence it pursues a southerly course for something over 60 miles, passing into Massachusetts. As it approaches the city of Lowell it makes a sharp and nearly right-angled turn to the east, and from thence maintains a direction considerably north of east for about 40 miles to the Atlantic Ocean, which it enters at Newburyport.

Its total length is 110 miles, of which $47\frac{1}{2}$ miles are in Massachusetts. The total drainage area is 5,015 square miles,¹ of which about 1,200 square miles are in Massachusetts and the remaining 3,815 square miles in New Hampshire. Its main tributaries with drainage areas in Massachusetts are the Powow (60 square miles), which enters from the north at Amesbury; and the Shawsheen (75 square miles), the Concord (402 square miles) and the Nashua (531 square miles), which enter from the south. The mouth of the Nashua is in New Hampshire, but the greater part of its watershed is in Massachusetts.

Of this total area of 5,015 square miles, 211 square miles have been diverted from the watershed for the metropolitan district and the city of Worcester, of which 93 square miles are from the Concord River and 118 square miles from the South Branch of the Nashua River above Clinton.

The mean annual rainfall on the watershed is about 40 inches,² varying from about 42 inches around Lawrence and

¹ United States Geological Survey, Water Supply Paper 415, p. 193.

² See Plate XXII., Rainfall in New England, by X. N. Goodnough, Journal of the New England Water Works Association, Vol. XXIX., September, 1915.

Lowell to about 38 inches in the upper portion of the river, although the precipitation increases again as the White Mountains are approached on the eastern slope of the headwaters. From 1880 to 1914, inclusive, the average yearly run-off of the Merrimack River at Lawrence was equivalent to 20.144 inches on the watershed, which was 48.2 per cent. of the mean annual precipitation at Lawrence of 41.51 inches, or about 50 per cent. of the estimated precipitation for the entire watershed. The average flow was 6,705 second-feet, or 1.4848¹ second-feet per square mile. The minimum weekly flow was 848 second-feet, or .19¹ second-feet per square mile, occurring during July, 1911.

In Massachusetts the Merrimack River passes by the following cities, the last three being the seat of important manufacturing industries, which in the cases of Lawrence and Lowell were fostered primarily by the water power developed at these two points.

NAME.	Population in 1915.
Newburyport, ...	15,311
Haverhill, ...	49,450
Lawrence, ...	90,259
Lowell, ...	107,978

Newburyport and Haverhill obtain their domestic water supply from local surface water sources; Lawrence uses filtered Merrimack River water; while Lowell is supplied from driven wells located near the river.

A profile of the river from Haverhill to Manchester, N. H., is published with this report. Tidewater extends from the mouth up to Haverhill, a distance of about 20 miles, and at high tide the effect extends some 4 miles above Haverhill to the upper end of Mitchells Falls, where mean low water with the mills in operation is about 11 feet above mean low tide, or 6.25 feet above mean sea level. From here to the lower lock at Lawrence there is a rise of about 2.8 feet when the flow of the river is low.

¹ Based on net drainage area during the period. This was 4,452 square miles in 1911.

The first power development on the river is at Lawrence, where an extreme head of 32.6 feet and an average head of about 28 feet are obtained. This development is later described in some detail.

From 4 to 5 feet of flashboards are usually carried on the dam at Lawrence, and the mill pond extends up-stream nearly 9 miles. Between the full pond level at Lawrence and tail-water at the Boott Mills at Lowell there is a rise of between 7 and 8 feet, the greater part of which occurs over a stretch of about a mile known as Hunts Falls. The fall here was formerly 11 feet, which has been reduced partly by removing reefs and partly by using higher flashboards at the Lawrence dam. These falls are owned by the Lowell mill corporations. At Lowell the total range between tail-water and full pond is 42 feet, but on account of the limiting level at which water in the canals can be carried, and the drop along them, this is reduced to an average effective head of between 36 and 37 feet. Four or 5 feet of flashboards are also carried on the Lowell dam, and from the top of these the full pond extends some 18 miles to the upper end of Cromwell's Falls, about $4\frac{1}{2}$ miles above the city of Nashua, N. H. From here to the foot of the development at Manchester there is an unimproved fall of 28 feet, which though not concentrated at one point is of sufficient amount to offer the possibility of development; but this is all in the State of New Hampshire. The 7 feet of undeveloped fall between Lawrence and Lowell can hardly be considered as a separate privilege.

Water Power at Lawrence.

A very complete description of the water powers at Lawrence and Lowell, together with a history of their development, was given by Prof. G. F. Swain in the report on the "Water Powers of the United States by the 1880 Census." This was revised to 1899 by Prof. Dwight F. Porter in an unpublished report to the United States Geological Survey on the Merrimack River. The present description is based on these two reports, supplemented and revised to date, through the kindness of Mr. R. H. Hale, first assistant engineer of the Essex Company at Lawrence, and Mr. Arthur T. Safford, engineer of the Proprietors of Locks and Canals at Lowell.

Much of the description is quoted verbatim from Professor Porter's report. For a more complete history of the development and details of construction reference is made to Professor Swain's account in the 1880 census.

The development of the water power at Lawrence dates from the year 1845, when the construction of the dam was undertaken by the Essex Company, through its agent and engineer, Mr. Charles S. Storrow.

The cost of dam, complete, was \$250,000. It crosses the river obliquely, just above the Broadway bridge, and is a masonry structure with a face of dressed stone resting upon solid rock. It was built upon a flat curve, with a chord of 900 feet and a center ordinate of about 15 feet. The maximum height above bed rock is $40\frac{1}{2}$ feet, the average about 32 feet, and upon the crest are supported flashboards, usually 4 feet in height, though at times this is increased to $4\frac{1}{2}$ or 5 feet. Connecting wing walls extend 300 or 400 feet down each shore, and on each shore there is an hydraulic power canal. The North, or principal, Canal is a trifle over a mile in length, decreasing in width from 100 feet near the head to 60 feet near the foot, where a waste-way permits emptying the canal into the Spicket River near the mouth of the latter. The bed of the canal slopes up from a center depth of 12 feet to a depth at the side walls of 4 feet, and has a nominal longitudinal gradient of 1 in 10,000. This canal, with its appurtenant structures, cost about \$250,000, and the principal mills are between it and the river on a strip of land from 300 to 400 feet wide.

The South Canal was started in 1866 and has been extended at various dates as the demand for mill sites made it necessary, until now the total length of the canal is 3,023 feet. The width is 60 feet for a length of about 2,000 feet, and then gradually reduces to 20 feet at the lower end. The depth is about 12 feet. From the lower end of the canal a steel riveted pipe about 2,650 feet in length conveys water to the Wood Worsted Mills and Pacific Print Works. The size of the pipe is: 7 feet diameter for about 460 feet; 6 feet diameter for about 1,920 feet; and 4 feet diameter for the remainder of the distance. No water wheels are connected with this penstock, it being used only for water for manufacturing purposes.

The slack water or pond above the dam extends nearly 9 miles up-stream, and has an area of about 29,000,000 square feet, or 667 acres. It is drawn down from 1 to $1\frac{1}{2}$ feet. The mills at Lawrence also obtain the benefit of the pondage above the dam at Lowell.

The crest of the dam is at elevation 34.12 on the company's scale, or 41.99 referred to United States Engineers' datum plane. The total fall embraced in the water privilege, measured from top of 4-foot flashboards to low water surface in the river at the outlet of the lower locks on the North Canal, is 32.6 feet, and measured to a point opposite the foot of the South Canal is 32 feet. The actual fall at the various mills is a foot or so less than these figures, but for ten months of the year is not likely to run below 27 feet. During freshets, however, it frequently drops to 20 feet for a few days, and in the remarkable freshet of April, 1852, sank for a few hours to 7 feet. This was the highest freshet known at this point until 1896, when, on March 3, the river attained a height about 3 inches greater opposite the foot of the North Canal, rising to 29.75 feet on the Essex Company's scale, against 29.50 for the freshet of 1852.

The Essex Company has disposed of its power on the basis of the "mill power," equivalent to 85.23 gross or theoretical horsepower available sixteen out of the twenty-four hours, and defined in detail in its leases as follows:—

Each mill power is declared to be the right to draw from the nearest canal or water-course of the grantors, and through the land to be granted, so much water as shall give a power of 30 cubic feet of water per second, when the head and fall is 25 feet; and no more is to be drawn in any one second, nor is the same to be drawn more than sixteen hours in each day of twenty-four hours; and in order to prevent disputes as to the power of each mill privilege in the variations of the height of water from changes in the season or other causes, it is understood and declared that the quantity of water shall be varied in proportion to the variation of the height, 1 foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them; thus on a head and fall of 30 feet the quantity of water to be used would be $24\frac{1}{4}$ cubic feet per second; and the respective parties, where either has any lawful interest therein, may at all reasonable times, in a peaceable manner, and after due notice to the principal steward or agent then on duty at any mill, enter the raceway thereof to measure and compare the quantity of water used with the quantity granted, and in the measurement all wastage shall be included.

A mill power was originally valued at about \$15,000, and most of the original grantees purchased their power on nominally that basis. In more recent years, however, the company has followed the plan of leasing its power at an annual rental of \$1,200 per mill power, equivalent to \$14.08 per gross horsepower. In all, 142½ mill powers have been sold or leased, corresponding to about 12,110 gross horsepower. In addition to the sales under the proposals there have been sales of about 2 mill powers to the Pacific Print Works, and .02 mill power to the Boston & Maine Railroad on the basis of 'million gallons.

The total "mill power" sold or leased is believed to be within the probable capacity of the river to supply at all times, and is classed as "permanent power." For more or less of the time, however, during all years the river can furnish a variable amount of additional power, which is classed as "surplus power," and which the Essex Company offers to those who have been granted permanent power. The use of surplus power is set forth in the following articles from the company's "Regulations for the Use of Surplus Water Power:" —

II. Any party who shall use any of such surplus water power shall pay therefor, for each day between the hours of 6 A.M. and 6 P.M. upon which such power shall be used, at the following rates, viz.: for each surplus mill power or part thereof not exceeding 50 per cent. of the amount to which the party is entitled by its indentures, at the rate of \$4 per mill power; and for each surplus mill power or part thereof in excess of such 50 per cent., at the rate of \$3 per mill power; and for each night between the hours of 6 P.M. and midnight upon which any of such surplus water power shall be drawn, the party so drawing shall pay for each surplus mill power or part thereof at the rate of 60 cents per mill power; and for each night between the hours of midnight and 6 A.M. upon which any water power is drawn or any water is wasted, the party so drawing or wasting shall pay for each mill power or part thereof at the rate of 60 cents per mill power. Subject, however, to the rates fixed by or under the following article.

III. The Essex Company, whenever in its opinion the supply of water renders it expedient as a matter of necessity or precaution, may limit the use of surplus water power by day to a certain percentage of the aggregate amount then granted by indenture as aforesaid, but such limitation shall be uniform in its application to all those grantors who shall then have agreed for the use of surplus power under these regulations, and shall be in proportion to the number of mill powers owned by them respectively. The Essex Company may limit the use of surplus water

power at night by the same methods prescribed for its limitation during the day, or it may limit the use at night upon one or both of its canals to specified hours, or prohibit its use. Any party using an amount in excess of such limitation shall pay at the rate of \$20 per mill power for each day or night on which such power or part thereof in excess of such limitation shall be used. The Essex Company or its engineer may at any time, by a notice in writing to the principal agent or superintendent then on duty at the mill, prohibit any such grantee from using water in excess of such limitation.

Table No. VI., on page 51, gives the details of the water-wheel installation at Lawrence. The total amounts to 25,535 horsepower based on a 30-foot head. The steam-power plants at these same mills show a total of 75,348 indicated horsepower, or approximately three times the capacity of the water wheels.

The running time of the mills under Massachusetts laws is fifty-four hours per week, distributed nine and three-fourths hours for five days and five hours on Saturday, closing at noon. This applies to textile mills in general. Paper mills ordinarily run continuously from 6 A.M. Monday to 6 P.M. Saturday. The electric light plant at Lawrence runs continuously during the week, including Sunday, both for light and power, the load being variable, with the maximum in the late afternoon and evening.

The amount of surplus power used varies with the season. In a dry time its use is sometimes restricted and divided according to the article above quoted. The Essex Company has applied restrictions to the use of leased power in varying percentages of the permanent power from 1880 to the present time. The time varies from thirty-four days in 1880 to one day during the year 1915. There were some periods when all surplus was cut off and the use of only the permanent power permitted, but this represented a very small percentage of the time. Restrictions are applied to the use of the water at night during periods of low flow, as retaining the water by the various dams above Lawrence would necessitate drawing on the storage in the Lawrence pond, thus reducing the head and power.

The flow of the river is computed for each day and the results are tabulated at the end of the calendar year, and are published in the United States Geological Survey Water Supply Papers, to which reference may be made. In the very dry year

of 1911 the lowest flow was an average of 1,190 second-feet for twenty-four hours during the month of July. During the working hours from 6 A.M. to 6 P.M. an average of 117 mill powers was drawn, and outside of working hours water was supplied for manufacturing and electric lighting for an additional 19 mill powers, making a total of 136 mill powers supplied during the working hours of the six working days. The power used in the working days during the week was benefited by the Sunday storage. At times when no restrictions are in force the amount of water drawn has reached 211 mill powers during the daily working hours and 56 mill powers during the night outside of the regular working hours.

The mills experience little trouble with ice, although the canal often freezes over at night, but it is cleared out in the morning before the mills start. Sometimes during a severe snowstorm with low water large masses of snow will collect and form jams that interfere with the flow of water, but the delays are very small, as the jams are broken up by a wave produced by a boat drawn by horses, and the snow is discharged through the wasteway at the lower end of the canal.

The method adopted in Lawrence for measuring the quantities of water drawn by the different mills is to gauge the quantity each day during the working hours and during the night between 6 P.M. and 12 P.M., and between 12 P.M. and 6 A.M. The evening and morning readings are necessary on account of the night charges for the use of surplus power.

Water Power at Lowell.

As early as 1792 a corporation was chartered known as the "Proprietors of The Locks and Canals on Merrimack River," for the purpose of making the stream navigable from tidewater to the New Hampshire line. This corporation still endures, and manages the distribution of water to the various mills and the maintenance of the general hydraulic works of the famous water-power system of Lowell. Within a few years after the chartering of this company it built the Pawtucket Canal past the falls. At first there was no dam, and the utilization of hydraulic power for manufacturing seems not to have been contemplated. The records indicate, however, that within ten

years the river was partially controlled by a low dam, and that at least as early as 1821 water power was used for operating a saw and grist mill; but it was not until 1833 that a relatively permanent structure of timber and stone was completed to the height of the present dam, controlling the entire width of the stream. In 1847 part of this dam was replaced by the present structure of stone masonry, and in 1875-76 the balance was so replaced. All this work of reconstruction was designed and carried out under the supervision of Mr. James B. Francis, whose connection with the company continued unbroken from Nov. 22, 1834, until his death Sept. 18, 1892.

The present dam is built of ashlar masonry with a vertical face, and a sloping capstone cut to give a level crest 18 inches wide upon which flashboards are supported. The capstone is doweled to the face stone beneath, and the bottom course of the face is similarly secured to bed rock. The maximum depth of the bed below the crest is about 38 feet, but in general it varies between limits of 16 feet and 2 feet. The length of the dam is 1,903.5 feet, due to following a very irregular course across the stream.

Two main canals extend on the south side of the river from the pond formed by the dam. The original Pawtucket Canal, subsequently enlarged, runs off at a right angle to the pond for about half a mile, and then turns towards the river, which in the meantime has made a right-angled bend; but before reaching the river the canal subdivides into several distributaries, the more distant of which encloses an area in the angle of the river measuring nearly a mile each way. The other main canal, the Northern, skirts the river for about 2,000 feet below the dam, being separated from the river for a considerable part of the distance by a heavy masonry wall 36 feet high in places, and thence turns inland. The head gates at the entrances to these canals provide an aggregate opening for the Pawtucket of 450 square feet, and for the Northern of 1,200 square feet, and in both cases are operated by hydraulic power, in the former by hydraulic rams directly attached, and in the latter by a turbine wheel acting through shafting and gearing upon the gate racks.

The canals, both main and subsidiary, are with a single ex-

ception open, and usually are walled on the sides, thus giving a rectangular cross-section. What is known as the Moody Street Feeder, however, connecting the Western and Merrimack canals, and about a quarter of a mile long, is arched over.

Table No. IX., on page 54, gives information regarding the various canals. Their total length is about 5 miles.

The crest of the dam is at elevation 82¹ on the company's scale, to which the elevations given below refer. Five feet of flashboards are used except during the months from March to June, inclusive, when only 4 feet are permitted, which makes the elevation of the pond, when full to the top of the flashboards, 86 during the spring months and 87 during the remainder of the year. The top foot of the flashboards is equipped with straddle pegs, so that in case the river rises they will be carried off without bending the boat pins supporting the lower 4 feet. If the head on the boards rises high enough the pins are bent and the boards carried away. It has been stated that the flashboards are liable to be carried away anywhere from three to a dozen times a year.

At elevation 87 the volume of pondage is about 50,000,000 cubic feet per foot of drawdown. The company prefers not to draw it lower than elevation 82, which gives a total of something under 250,000,000 cubic feet.

Tail-water in the river below the Boott Mills is at about 45.2 with the wheels running at full capacity, but in times of very low water it may fall as low as 43.3. This gives 42 feet as the total fall, but under operating conditions deductions must be made for the lower permissible water level in the canals, the fall or drop along them, and the rise of tail-water, which leaves a net head of from 36 to 37 feet that can usually be obtained. Tail-water rises from 5 to 10 feet during the spring freshets, but in 1852 and 1896 it rose to elevation 64, or nearly 20 feet above normal conditions. At the latter time there was about 13 feet depth of water pouring over the dam.

The water level in the Pawtucket Canal cannot be maintained above elevation 82.5, and is regulated by the head gates at the upper end. The water level in the Northern Canal can be

¹ Elevation 90.47 referred to United States Engineers' datum plane. United States Engineers' zero is about 3.283 feet below mean sea level at Newburyport, and 0.567 feet above mean low water.

carried to elevation 85, but there is a loss of about 2 feet due to the drop along the canals. The fall from the upper to the lower level canals is from 13 to 14 feet, and from the lower level to the river from 21 to 23 feet. About one-sixth of the water is used on a single fall from the Northern Canal to the river under an average head of about 37 feet.

Permanent power in varying quantities was granted in 1853 to the several manufacturing companies holding the stock, and in proportion to the stock owned, to the amount of $139\frac{1}{6}$ mill powers,¹ or 3,595.28 cubic feet per second, during working hours under ordinary falls, this being the estimated amount of power the river would supply in the driest seasons. The power actually allowed to be drawn has been limited to this amount on a very few occasions. Generally the companies are allowed to draw additional power known as surplus power. The capacity of the canals formerly limited the amount of surplus power to 40 per cent. of the permanent power, but their capacity has been increased so that they will now carry 180 per cent. surplus power.

The leases of permanent power are essentially similar to those at Lawrence, and the regulations for the use of surplus power are in general similar to those at Lawrence, except in the matter of prices, which vary from time to time by vote of directors, depending upon expenses. The data for measuring power drawn are secured by running floats in flumes in the canals and raceways several times a year, and by daily observations upon the height of speed gates of the several water wheels and the fall acting upon them. The quantity drawn by each wheel is then determined twice a day by means of diagrams similar to those in use at Lawrence.

Table No. VII., on page 52, gives the details regarding the mills and power at Lowell. As at Lawrence they ordinarily run

¹ A mill power at Lowell is defined as "the right to draw from the nearest canal of the said Proprietors so much water as, during fifteen hours in every day of twenty-four hours shall give a power equal to 25 cubic feet per second at the great fall when the head and fall there is 30 feet; to 45.5 cubic feet per second at the lower fall when the head and fall there is 17 feet; and to 60.5 cubic feet per second at the middle fall when the head and fall there is 13 feet. And in order to prevent disputes as to the power of each mill privilege in the variations of the height of water from changes of the season or other causes, it is understood and declared that the quantity of water shall be increased in proportion to the reduction of the height, 1 foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them."

fifty-four hours a week, from 6.45 to 12, and from 1 to 5.30, except on Saturday, when the hours are from 6.45 to 12.

The method of operation in times of low water is to start with a full pond Monday morning, which utilizes a part at least of the Sunday flow. It is then gradually drawn down until it reaches its lowest level at the end of the week. Under these conditions the night flow can be completely ponded.

The total load when all the mills are running full is about 40,000 horsepower. The total installed capacity of water wheels amounts to 29,943 horsepower, but as a part of the wheel capacity is used for governing, and the loads on the two levels are not exactly balanced, only about 24,000 horsepower is actually obtained from the wheels at a given time, even when there is plenty of water in the river. The difference between the total load and the power supplied by water is made up by steam power, of which the mills have a combined capacity of about 25,000 horsepower.

Storage on the Merrimack River.

The greater part of the watershed of the Merrimack River is in the State of New Hampshire; therefore the principal storage reservoirs are also located in that State, and it was considered that the scope of this investigation did not call for detailed examination of this storage, or an investigation covering the possibilities of increasing it. Professor Porter states in his report, previously referred to, that there are some 270 lakes in the watershed of the Merrimack, counting in general only those of more than 40 acres in extent. These lakes have a combined area of 117,165 acres, or 183 square miles, constituting 3.65 per cent. of the entire drainage area of the river.

Of this 183 square miles of water surface, 133 are above the formation of the main stream at the junction of the Pemigewassett and Winnepesaukee rivers at Franklin, N. H., and amount to nearly 9 per cent. of the corresponding drainage area, which includes, with the exception of Massabesic Lake and Wachusett Reservoir, all of the reservoirs of more than 1,000 acres in the entire basin.

The main facts regarding the principal lakes are shown in Table No. VIII., on page 53. Lake Winnepesaukee and possi-

bly Squam Lake and Newfound Lake were originally controlled by a combination of the water-power companies lower down the Merrimack, and were so operated as to give the best results on the river at Lowell. However, on account of laws passed by the New Hampshire Legislature the control of these reservoirs was given up by this combination, and each is now controlled by mills located on their respective outlets; but the general policy is to maintain as nearly a constant flow as possible throughout the year.

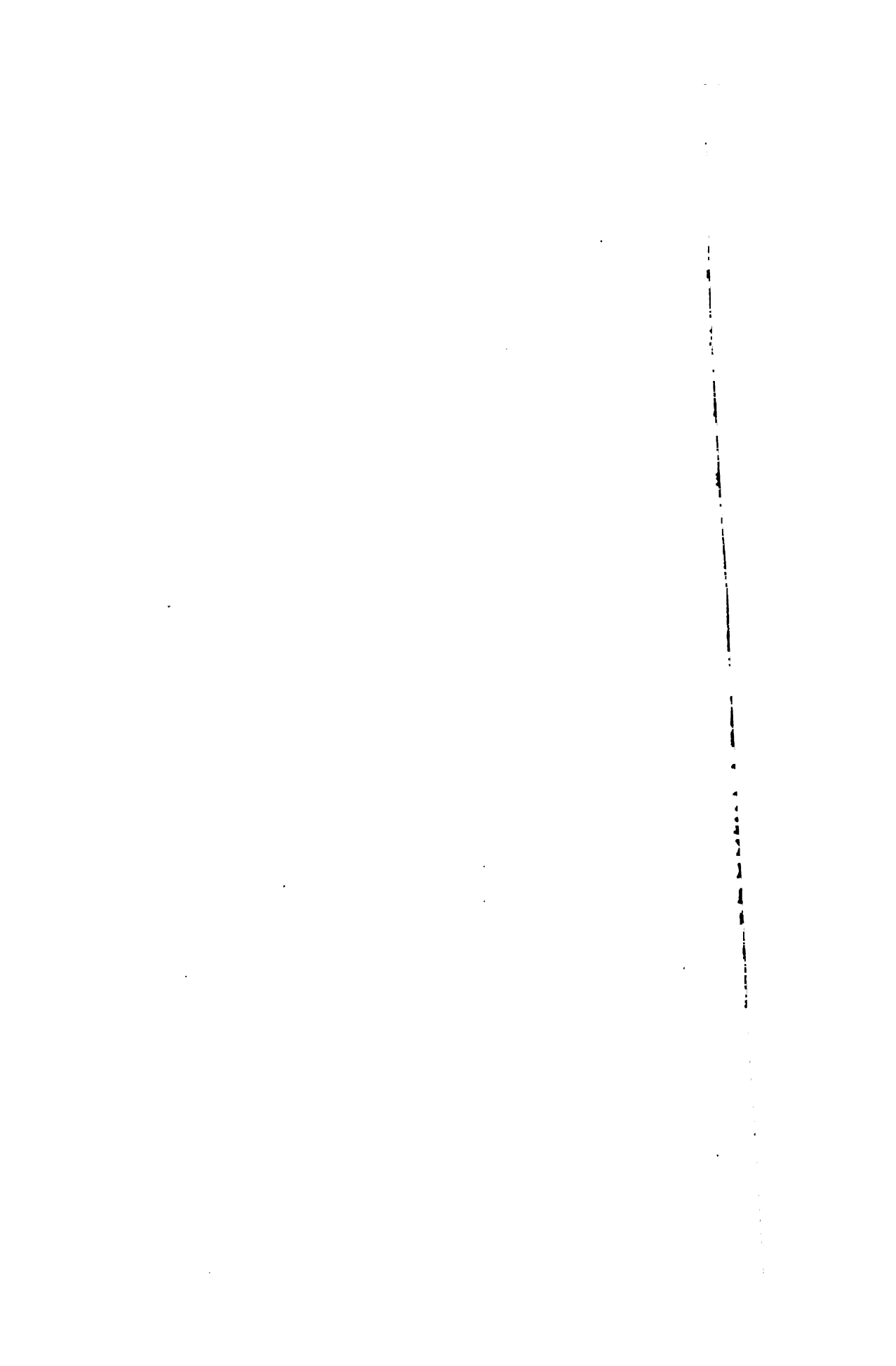


TABLE VI. — *Water Power on the Merrimack River in Massachusetts at Lawrence.*
[§. Indicates steam.]

NAME OF COMPANY.	Product.	Number of Working Hours.	Average Head (Feet).	Rated Horsepower of Water Wheel. ¹	Auxiliary Horsepower.	Remarks.
Pacific Mills (upper site).	Textiles.	0	28	3,032	14,000 h.	North Canal.
Pacific Mills (Atlantic site).	Textiles.	0	28	3,306	—	North Canal.
Pacific Mills (lower site).	Woolens.	0	28	2,117	2,200 h.	North Canal.
American Woolen Company (Washington Mills).	Woolens.	0	28	3,509	7,500 h.	North Canal.
Pemberton Company.	Cotton goods.	0	28	1,116	300 h.	North Canal.
Lawrence Duck Company.	Cotton goods.	0	28	1,316	1,100 h.	North Canal.
Everett Mills.	Cotton goods.	0	28	1,417	5,000 h.	North Canal.
George E. Kunhardt.	Woolens.	0	28	347	334 h.	North Canal.
George E. Kunhardt (Davis site).	Woolens.	0	28	350	—	North Canal.
Wright Manufacturing Company.	Woolens.	0	28	70	65 h.	North Canal.
George E. Kunhardt (Battles site).	Woolens.	0	28	113	13 h.	North Canal.
George W. Hamblet.	Machine shop.	0	28	76	35 h.	North Canal.
Chapman-International Company.	Paper.	24	28	1,006	1,500 h.	North Canal.
Eases Company (Spicket Mill).	Pumps.	0	28	74	—	North Canal.
Plymouth Mills.	Rugs.	0	28	520	—	North Canal.
United States Worsted Company (Uxwood site).	Worsted goods.	0	28	336	—	South Canal.
Munroe Felt and Paper Company.	Paper.	0	28	627	173 h.	South Canal.
Merrimack Paper Company.	Paper.	24	28	645	550 h.	South Canal.
American Woolen Company (Prospect Mills).	Woolens.	0	28	390	150 h.	South Canal.
United States Worsted Company (dye works site).	Woolens.	0	28	392	600 h.	South Canal.
Lowell Bleachery.	Bleachery.	0	28	586	373 h.	South Canal.
E. Frank Lewis.	Wool scouring.	0	28	550	550 h.	South Canal.
L. Frank Lewis.	Electricity.	24	28	3,252	11,500 h.	South Canal.
Ayer Mills.	Woolens.	0	28	None	6,400 h.	South Canal.
American Woolen Company (Wood Worsted Mills).	Woolens.	0	28	None	18,000 h.	South Canal.
Pacific Mills (print works department).	Cotton goods.	0	28	None	4,500 h.	South Canal.
Boston & Maine Railroad.	—	—	—	None	—	Small quantity of water purchased for locomotives.
Total.	—	—	28	25,535	75,348	

¹ Figures in this column give rated horsepower under 30 feet head.

Net drainage area, 4,462 square miles after deducting 211 square miles diverted for water supplies; total drainage area, 4,663 square miles.

Discharge in second-foot per square mile, 80 per cent. efficiency, 2.25. Area of ponds, 667 acres.

TABLE VII. — *Water Power on the Merrimack River in Massachusetts at Lowell.*

NAME OF COMPANY.	Product.	Number of Working Hours.	Average Head (Feet).	Rated Horsepower of Water Wheels.	Remarks.
Merrimack Manufacturing Company,	Cotton goods,	9	26	4,915	Upper level canal to river.
Hamilton Manufacturing Company,	Cotton goods,	9	14	2,021	Upper level to lower level canal.
Appleton Company,	Cotton goods,	9	13	1,666	Upper level to lower level canal.
Biglow-Hartford Carpet Company,	Cotton goods,	9	14	1,333	Upper level to lower level canal.
Saco-Lowell Shop,	Carpets,	9	13	587	Upper level to lower level canal.
Middlesex Company,	Cotton machinery,	9	21	594	Lower level canal to river.
Boott Mills,	Woolens,	9	21	3,345	Lower level canal to river.
Massachusetts Cotton Mills,	Cotton goods,	9	21	7,477	Lower level canal to river.
Tremont & Suffolk Mills,	Cotton goods,	9	14	2,853	Upper level to lower level canal.
Tremont & Suffolk Mills,	Cotton goods,	9	23	2,128	Lower level canal to river.
Lawrence Manufacturing Company,	Cotton goods,	9	21	2,340 ¹	Lower level canal to river.
Total,	-	-	26	20,943 ²	-

Net drainage area, 3,979 square miles after deducting 118 square miles taken on South Branch of Nashua River for metropolitan district; total drainage area, 4,097 square miles.

Discharge in second-feet per square mile, 80 per cent. efficiency, 2.23.

Area of ponds, 1,148 acres.

Auxiliary horsepower approximately 25,000.

¹ New installation being put in. This is old installation.

² Includes grist mill of 88 horsepower.

TABLE VIII. — *Principal Storage Reservoirs on Merrimack River Watershed.*

NAME OF LAKE.	By whom controlled.	Drainage Area (Square Miles).	Area (Square Miles).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
Winnepesaukee, . . .	Winnepesaukee Lake Cotton and Woolen Manufacturing Company.	360.0	71.80	4	8,000	Equivalent of 450 second-feet; 24-hour flow can usually be maintained. ¹
Merrymeeting, . . .	—	11.7 ²	3.25	—	—	—
Smiths Pond, . . .	Winnepesaukee Lake Cotton and Woolen Manufacturing Company.	36.5 ²	4.25	7	—	—
Wukawan, . . .	American Flax Company, . . .	10.5 ²	1.75	6	—	—
Squam, . . .	Kusumpe Lumber Company, . . .	57.5	15.00	5	—	A twenty-four-hour flow of 75 second-feet, Sundays excepted, maintained as long as lake will supply it.
Newfound, . . .	Bristol Water Power Company, . . .	91.0	7.00	6	—	A twenty-four-hour flow of 100 second-feet, Sundays excepted, maintained as long as lake will supply it.
Great Masabesic, . . .	City of Manchester, . . .	44.0	3.80	3	—	Water supply for Manchester, N. H.
Wachusett Reservoir, . . .	Metropolitan Water and Sewerage Board,	118.0	6.50	—	8,680	Water supply for metropolitan district.

¹ An act passed by the New Hampshire Legislature and approved April 7, 1911, provides that between June 1 and September 15 of any year not more than an average of 250 second-feet for any week shall be drawn from the lake when the level is 21 inches or less.

² Tributary to Lake Winnepesaukee.

TABLE IX. — *Canals at Lowell.*

NAME.	Shape of Cross-section.	Approximate Length (Feet).	Approximate Depth (Feet).	Approximate Width (Feet).	Level.
Pawtucket, upper level,	Irregular, ...	6,745	11	80-90	Upper.
Pawtucket, lower level,	Rectangular, ...	2,040	7-12	100	Lower.
Hamilton, ...	Rectangular, ...	1,880	10-15	50	Upper.
Eastern, ...	Rectangular, ...	1,920	9	42-66	Lower.
Northern, ...	Rectangular, ...	4,400	18-23	100	Upper.
Western, ...	Rectangular, ...	3,195	11	30-57	Upper.
Western, ...	Rectangular, ...	1,000	8	30	Lower.
Merrimack, ...	Rectangular in part, and irregular in part.	3,400	10	40-50	Upper.
Lowell, ...	Rectangular, ...	500	10	30	Upper.
Moody Street feeder,	Rectangular in part, and arched in part.	1,390	10 ¹	30	Upper.

CONNECTICUT RIVER.

The Connecticut River rises in the Connecticut lakes in northern New Hampshire, and flows southward between New Hampshire and Vermont, and across Massachusetts and Connecticut into Long Island Sound. It is the largest river in New England except the St. John, is about 345 miles long, and drains an area of 11,345 square miles, which is distributed as follows: —

	Square Miles.
Canada, ...	105
New Hampshire, ...	3,120
Vermont, ...	3,970
Massachusetts, ...	2,720
Connecticut, ...	1,430

11,345

The important tributaries of this river, with drainage areas in Massachusetts, are the Chicopee (721 square miles) and the Millers (394 square miles), which enter from the east; the Westfield (515 square miles) and the Deerfield (665 square miles), which enter from the west. The Farmington is the more important tributary which enters in Connecticut, the upper part of this basin extending into the State of Massachusetts between the watersheds of the Housatonic and Westfield rivers.

From its headwaters in the Connecticut lakes to Long Island the Connecticut falls about 1,900 feet.²

¹ Center.² United States Geological Survey, Water Supply Paper 415, pp. 40, 41.

With the exception of about 176 feet this fall all occurs north of Massachusetts.

The mean annual rainfall varies from about 46 inches in the lower part of the basin to from 34 to 36 inches at the headwaters, with an average for the entire basin of about 40 inches. The longest period of run-off records available are those kept at Holyoke, extending from 1880 to 1899, inclusive. During this period the average flow was 12,240 second-feet, or 1.46 second-feet per square mile. During the same period the Merrimack River at Lawrence had a mean flow of 1.56 second-feet per square mile.

The Connecticut River has been carefully surveyed from its mouth to the northern Massachusetts line in connection with investigations for rendering the river navigable.

The results of these surveys are given in the following documents: —

United States Government Publications.

H. Ex. Doc. No. 101, 45th Congress, 2d session (1878), contains plans and survey by Gen. Theodore G. Ellis 1871-74.

H. Doc. No. 136, 55th Congress, 2d session (1897). Plans for canalization made by Maj. Smith S. Leach.

H. Doc. No. 231, 58th Congress, 3d session (1905). Report of Board of Civil Engineers on Improvement of Connecticut River above Hartford, with survey made by Mr. Arthur J. Ober, Junior Engineer, in 1903.

H. Doc. No. 1294, 61st Congress, 3d session (1911). Report of Maj. Harry Taylor of a survey of the Connecticut River up to Hartford.

H. Doc. No. 417, 64th Congress, 1st session (1915). Report of Maj. G. B. Pillsbury on survey and examination of the Connecticut River between Hartford and Holyoke.

Publications by Commonwealth of Massachusetts.

1898. House No. 907. Report of Harbor and Land Commissioners on Improvement of Navigation on the Connecticut River between Hartford, Connecticut and Holyoke.

1913. Report of the Connecticut Valley Waterway Board on an Investigation of the Connecticut River.

1914. Public Document No. 11. Thirty-fifth annual report of the Board of Harbor and Land Commissioners for the year 1913. Pages 39 to 42 briefly cover surveys from Holyoke to Massachusetts-Vermont-New Hampshire line, made by engineers of Harbor and Land Commission during 1913.

Tidewater extends from the mouth of the river up to and above Hartford, a distance of about 50 miles. Low water at Hartford as determined by General Ellis in 1872-78 is 0.09 feet above mean sea level at Long Island Sound. From Hartford to the foot of Enfield Rapids, a distance of some 10 miles, the river runs smoothly with a low water slope of about 6 inches per mile. The Enfield Rapids extend $5\frac{1}{2}$ miles up-stream, with a maximum fall at an extreme low stage of about 35 feet.

A dam and canal extending around the Enfield Rapids have been maintained for many years by the Connecticut River Company. This company was chartered by the State of Connecticut in 1824, in an act in which it was provided —

That the said corporation, for the purpose of widening the channel of said river and deepening the same, shall have power to dig, cleanse, and remove obstructions from the channels and bars of said river, from and above the bridge at Hartford, to Springfield, and to erect and build wharves and piers and hedges in said river, or on the banks thereof; and the said corporation are empowered to lock the falls at Enfield, on said river, and to make channels to aid them, and to construct a canal on either bank of said river near said falls, and to construct a dam or dams for the purpose of entering or leaving the locks in still water; provided the extension and form thereof shall be such as shall not prevent the convenient passage of boats and lumber down the river, nor obstruct the passage of fish.

The Connecticut River Company gradually passed from a navigation company into a water power company, selling water to mills located between the lower end of the canal and the river in the town of Windsor Locks. The original dam consisted of two wings extending from either side of the river, with a gap of 155 feet between them to serve as a fishway and to permit navigation. At the time of General Ellis's survey (1871-74) the average elevation of the top of the dam was about 39 feet above the United States Engineers or "Ellis base" at Hartford, and the opening between the two wings had been partly filled with stone. "At the lowest water nearly or quite the whole volume passes through this opening at a level of about 38 feet above the Hartford Zero."¹ In the early 80's the gap was further closed and the dam raised, which resulted in litigation between the Connecticut River Company and the

¹ Page 53, Ex. Doc. No. 101, 45th Congress, 2d Session, "Survey of Connecticut River."

water-power interests at Holyoke and Chicopee. This was described by Mr. Clemens Herschel in the 1884 report of the Harbor and Land Commissioners, as follows: —

An act of the Connecticut Legislature, passed in 1881, undertook to give this company (the Connecticut River Company) the right to close the gap between the two wing dams, and to raise the whole dam 15 inches higher still. This was resisted in the Circuit Court of the United States for the District of Connecticut by the Holyoke Water Power Company, by the Dwight Mills of Chicopee, and by the town of West Springfield; and Judge Shipman, in his opinion filed April 23, 1884, orders "a decree enjoining the defendant against any further raising of its present dam, and against constructing a new dam or dams to a greater height than the height occupied by the respective portions of the present structure." He allows the defendant to keep, however, so much of the fall of the river as it had taken against the protests of the plaintiffs, and even in violation of the first temporary injunction of the court, and before the proceedings to permanently enjoin such action could be fairly set in motion; which, in times of low water, amounts to about a foot at West Springfield or at Holyoke, making a total encroachment upon the drainage facilities of Springfield and of West Springfield, and upon the water power of Holyoke, between 1855 and 1882, of about two feet and a half.

In 1903 the river was again surveyed by the Army Engineers under the direction of Mr. Ober, and at that time the dimensions and elevations of the Enfield Dam were as follows: —

A survey of Enfield Dam was made to determine its shape, height and condition. This was done at very low water, when the depth on the crest was from 0.2 to 1 foot. About 40 points on its crest were located by two transits from the ends of a base line on the east shore, and the elevation of each point determined by level.

The dam is a low cribwork structure about 5 feet high, irregular in plan and uneven in profile. It extends from the east shore nearly at right angles to the course of the stream for about 610 feet, and then runs south-west diagonally downstream about 870 feet, to the head gate house of the Enfield Canal. A gap, or fishway, 43 feet wide, is in the easterly portion, about 525 feet from the east shore. The structure has been changed both in plan and elevation since General Ellis's survey, the angle point at the northwest corner having been moved southerly, the gap or fishway relocated and made narrower, and the whole structure raised. Its present crest elevation and length are shown by a drawing on the general map, and also by the following table: —

PORTION.	Length (Feet).	Average Elevation above Hartford Zero (Feet).
Crest, omitting fishway and end slopes, ...	1,320	40.925
Crest of end slope on west end of dam, ...	85	41.25-43.650
Crest of end slope on east end of dam, ...	30	41.00-43.800
Crest, omitting fishway but including end slopes, ...	1,435	41.040
Crest of fishway, ...	43	40.630
Crest, total, including end slopes and fishway, ...	1,478	41.010

It is in fairly good condition except for a few holes in the top planking and stone filling.¹

The following description of the canal extending from the dam down to Windsor Locks is also taken from Mr. Ober's report. The total length of the canal is 5.3 miles. The width varies from 80 to 120 feet, except through the village of Windsor Locks, where mills, tow path, railroad and highway are closely crowded together, reducing the canal width to about 50 feet. The average depth at the center throughout this entire length is about 12 feet. The velocity of water in the canal is about 2 miles per hour, or 3 feet per second, and the total drop in head about 3.3 feet. The normal water surface at the upper end is at elevation 40.9, and at the lower end 37.6. The tail-water of the mills ordinarily varies from elevation 10 to elevation 13, and the average yearly head at the mills is about 26.7 feet, corresponding to a height of water in the canal of 37.7, and in the river of 11 feet above the United States Zero at Hartford.

In a letter of Mr. D. M. Green,² engineer of the Connecticut River Company, to the Board of Civil Engineers on Improvement of Connecticut River above Hartford, dated Oct. 6, 1902, he stated that the present canal is capable of delivering more than 1,522 cubic feet per second, and that at that time (1902) 1,420 cubic feet were in use at Windsor Locks, which he stated represented 3,267 net horsepower.

¹ Pages 36, 37, House Doc. No. 231, 58th Congress, 3d Session, "Report of a Survey of the Connecticut River between Hartford and Holyoke."

² Page 18, House Doc. No. 231, 58th Congress, 3d Session, "Report of a Survey of the Connecticut River between Hartford and Holyoke."

Plans have been under consideration by the Connecticut River Company for a redevelopment in connection with canalization of the river by the building of locks of sufficient capacity to meet the requirements for river traffic at the present time. It is estimated that when redeveloped the river at this point will be capable of an installation of 25,000 horsepower.

Still water extends up the river 18 miles from the Enfield Dam practically to the foot of the canals at Holyoke, where the first power development on the river in Massachusetts is located. A total head of 56 to 58 feet is developed at this point by means of a masonry dam and three levels of canals on the west side of the river, and a short canal on the east side at South Hadley. The details of the development are given in the succeeding pages.

From the top of the flashboards on the dam at Holyoke to low tail-water at the new power station at Turners Falls, a distance of about 34.5 miles, there is a rise of from 7 to 8 feet. Just where the Holyoke pond runs out it is difficult to say.

From observations taken during the Harbor and Land Commissioners' survey of 1913, it appears that when full to top of flashboards (elevation 100.5 on Hartford base) the water backs up about 25 miles to a point just above the Sunderland bridge. In extreme low water stages the water surface at Montague City railroad bridge, about 8 miles above the Sunderland bridge, is about elevation 104 feet above Hartford base, and there is an additional rise of 3.5 to 4 feet at the new power station of the Turners Falls Power Company about three-quarters of a mile above the railroad bridge at Montague City.

A head of 58 to 59 feet is developed at Turners Falls by a dam and a canal some 2 miles long, extending to the lower end of the rapids which occur in the river at this point. This development is described on pages 65 to 69.

The dam at Turners Falls was raised 3 feet in 1912, and provisions were made for $4\frac{1}{2}$ to 5 feet of flashboards, which will raise the water sufficiently to completely flood the French King Rapids, and when the pond is full it extends above the Massachusetts-Vermont-New Hampshire line nearly to the Vernon plant of the Connecticut Power Company, 5 miles above the State line. At Vernon a fall of about 30 feet is developed,

above which there is another flat stretch of river. The attached profile of the river shows these facts, and also gives the elevations of the various dams and other points along the river.

Water Power at Holyoke.

In the 1880 census, Vol. XVI., Part I., Prof. Dwight Porter gives a very complete description of the Holyoke water power development as it existed at that time, and its history prior to that date. Between 1891 and 1896 the timber dam built in 1849 was replaced by a fine masonry dam which is described in a paper by Mr. Albert F. Sickman, hydraulic engineer of the Holyoke Water Power Company in Vol. XVIII., No. 4 (December, 1904), "Journal of the New England Water Works Association." These reports, with a few changes bringing them up to date, are briefly summarized as follows: —

The first dam across the Connecticut River at Holyoke was constructed by the "Proprietors of Locks and Canals on the Connecticut River," under a charter granted in 1792. A timber dam was built a mile and a half above the site of the present dam, and a canal was constructed on the South Hadley side of the river, to enable boats to pass the falls at that point. In 1848 the stock of the "Proprietors of Locks and Canals on the Connecticut River" was acquired by the Hadley Falls Company, which was organized for the purpose of developing the water power. A timber dam was built and the gates closed on Nov. 16, 1848, in the presence of from 1,500 to 2,000 witnesses. When the water had risen to within 2 or 3 feet of the top, all but about 175 feet of the dam rolled over and was carried down the river. The loss to the company was about \$38,000.

A new timber dam was built in 1849, which still stands in the river in its original position, although submerged by the construction of the masonry dam a short distance below it. The first steps towards the erection of the present masonry dam were taken in 1891, and it was completed in 1896. This "dam is 1,020 feet long at the spillway, 30 feet high above bed rock at the back, and 54 feet wide on the bottom. The back is stepped off 1 foot in 5 all the way to the top, as a batter, the steps affording footings for coffer dams during course of construction. . . . The body of the dam is of rubble, laid in

Portland cement mortar. The spillway, upper face, and 5 feet of the top are of heavy granite blocks, those at the lower part of the spillway being fastened together with galvanized iron dogs, while those on top are secured with iron dowels.”¹

The greater part of the water power is developed on the Holyoke side of the river by means of the canal system laid out on the area enclosed by the bend of the river, though some power is used in one lift by mills located below the South Hadley end of the dam.

The canal system on the Holyoke side comprises three levels provided with waste weirs discharging from one canal to the other and to the river. The first or upper level runs at a distance of from 2,800 to 3,400 feet from the river, and has a total length of about 6,200 feet. It decreases in width from 150 feet near the bulkhead to about 105 feet at the lower end. The water is about 20 feet deep near the bulkhead, but through the main portion of the canal the depth is uniformly about 10 feet. It is walled with stone laid dry throughout its length. The fall between this level and the second is 20 feet. Near the upper end a few mills draw from it, discharging directly into the river, thus obtaining falls of from 32 to 40 feet.

The second level runs parallel to the first and 400 feet nearer the river, a straight reach of 6,500 feet, and then continues parallel to the curving course of the river and 500 feet distant from it for a further distance of about 5,400 feet. Its width decreases from 150 feet at the upper end to 90 feet at the lower end of the straight reach, and is between 140 and 150 feet wide throughout the curved portion. The water depth is uniformly about 8 feet. The supply of water comes from the first level, partly as tail-water from the mills, and partly from the waste-weir and gates between the two levels. The fall between the second and third levels is 12 feet, and from the second level to the river, from 20 to 33 feet.

The third level begins at the end of the curved portion of the second level, and for the greater part of its course runs parallel to the river at a distance of about 500 feet from it. Its total length is about 3,900 feet, its width about 100 feet and the depth of water 8 feet. The fall from this level to the river is

¹ Journal of New England Water Works Association, Vol. XVIII., p. 344.

substantially the same for all the mills using it, varying according to the stage of the river. During low-water stages it amounts to 23 or 24 feet, though at times it has been reduced to as low as 6 feet.

The crest of the dam is at elevation 97.975,¹ but when the maximum of about 2½ feet of flashboards is used the top is at about elevation 100.5. The water level in the first level canal is usually maintained at about the same elevation as the crest of the dam, or at about elevation 98; that in the second level at about elevation 78; and that in the third level at about elevation 66. Tail-water in the river at the outlet of third level canal varies from elevation 42 to elevation 60, with an average of elevation 44, except during the spring months. Between the crest of the dam and extreme low water in the river opposite the lower mills there is a total difference in elevation of 56 feet. All elevations refer to the Hartford base.

When full to the top of flashboards the pond extends upstream to the vicinity of Hatfield Ferry, with an area of 2,240 acres.² At the crest of the dam the area is reduced to about 1,500 acres. At times the water is drawn 3 feet below the crest of the dam, or to elevation 95, which reduces the head at the mills taking the water from the first level by about 3 feet. The additional pondage gained by the use of flashboards is relatively small on account of a narrowing of the river at a point known as the "ledge," not quite 3 miles above the dam, which practically divides the pond into two parts and renders the stored waters of the upper part only slowly available.

The total water wheel installation at Holyoke amounts to 47,578 horsepower. The distribution of this power in regard to location and number of hours used is shown by the following table furnished by Mr. A. F. Sickman, hydraulic engineer, Holyoke Water Power Company, together with the information that follows regarding the use of water in 1916:—

¹ Datum plane is Hartford United States Zero (approximately low water as determined by Ellis, 1872-78). Add 2.025 feet to refer elevations to Holyoke Water Power Company base on which the crest of the dam is at elevation 100.

² Determined from 1913 survey by Board of Harbor and Land Commissioners.

Water Power on the Connecticut River at Holyoke.

LOCATION.	Head.	HYDRAULIC HORSE-POWER.		Total.
		Twenty-four-hour.	Ten-hour.	
First level to river, ...	32-40	4,340	269	4,609
First level to second level, ...	20	11,556	7,314	18,870
Second level to river, ...	20-33	11,204	1,385	12,589
Second level to third level, ...	12	2,682	1,464	4,146
Third level to river, ...	23-24	6,564	800	7,364
Totals, ...	—	35,346	11,232	47,578

The use of power is such that a flow of 8,100 second-feet can be used during the working hours of the day, and a flow of 5,350 second-feet during the night. If all of this could be used on the full effective head of 54 feet at 80 per cent. efficiency, it would mean a load of 39,700 horsepower during the day and 26,300 horsepower during the night; but unbalanced loads among the various levels, and the reduced head at the mills discharging directly into the river, will make the actual output considerably less. During the ten years 1906 to 1915, inclusive, water wasted over the dam at Holyoke 65 per cent. of the time, or 7.8 months of an average year.

The following description of the conditions under which the water is sold to the mills by the Holyoke Water Power Company is taken from Mr. Sickman's paper previously referred to:—

The mill corporations hold their power under a form of lease or grant that is especially interesting, as it is perpetual, and is put on the county records in the same way as any other deed. Every grant of power carries with it the land necessary for the mill buildings, and the price is based only upon the amount of power, and not upon the amount of land conveyed.

In many of the older grants, covering what is now known as permanent power, the consideration was a lump sum, sometimes called a bonus, or \$5,000 per mill power and an annual rental of \$300 or of \$450 forever, according as the power granted was for sixteen or twenty-four hours. Many changes were made from time to time in the bonus as well as in the rentals, and at the present time permanent power would demand a much higher price than that realized fifty years ago.

The term "mill power," just used in speaking of the rentals, was derived as follows: —

The second mill built at Waltham contained 3,584 spindles, with all the apparatus necessary to spin No. 14 yarn and convert it into cloth, which was taken as a standard, and the necessary water power estimated and established as the right to draw 25 cubic feet per second on a fall of 30 feet, or a gross horsepower of 85.05, supposed to net about 60 horsepower.

As the original intention of the Hadley Falls Company was to build a city devoted almost entirely to the manufacture of cotton, it was but natural that the power unit in general use among New England manufacturers should be adopted here, and it was adopted with very slight change, and carefully defined in Article II. of the proposals, which I now quote: —

Each mill power at the respective falls is declared to be the right, during sixteen hours in a day, to draw from the nearest canal or water-course of the grantors, and through the land to be granted, 38 cubic feet of water per second at the upper fall, when the head and fall there is 20 feet, or a quantity inversely proportionate to the height at other falls. And in order to prevent disputes as to the power of each mill privilege in the variations of the height of the water from changes of the seasons or other causes, it is understood and declared that the quantity of water shall be increased in proportion to the reduction of the height, 1 foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them. Thus on a head and fall of 32 feet the quantity of water used would be 23 cubic feet, and to be $\frac{1}{4}$ part of a cubic foot per second. And the respective parties, where either has any lawful interest therein, may, at all reasonable times, in a peaceable manner, and after due notice to the principal steward or agent then on duty at any mill, enter the raceway thereof to measure and compare the quantity of water used with the quantity granted, and in the measurements all wastage shall be included; and may also adopt and use such other mode of making or verifying the said measurement as the circumstances of each particular case may require.

Articles III. and IV. declare that the grantors must forever keep in good repair the principal canals, and must forever maintain a dam across the Connecticut River, of such length and height as may be necessary to turn the water into the canals; also that the flumes and raceways are the property of the respective grantees, to be built and maintained by them in good repair.

Article V. reads: —

In order to continue in the grantors an interest in common with the grantees for the preservation and support of the mill powers which may be granted, and to secure a fund to indemnify the grantees for expenses which may be incurred by them for making repairs, if the grantors should improperly neglect to make them, it is proposed that part of the consideration of every sale, and all that is to be allowed the grantors for repairs, etc., by them assumed, should be paid or secured to them in the form of a reservation of rent. It is therefore declared that each mill power, with the land to which it is annexed, shall forever be subject to a perpetual annual rent of at least 260 ounces, troy weight, of silver of the present (1859) standard fineness of the silver coin of the United States, or an equivalent in gold,

at the option of the grantee at the time of payment; which rent is to be paid in yearly payments forever, free from all charges or deductions whatever for taxes or assessments of every description which may be assessed or levied upon any granted premises after the making of the deed, all of which are assumed by the grantees. And a perpetual annual rent, at least equal to the above, shall be reserved for every mill power hereafter sold.

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"Surplus power," which is offered for sale to owners of the so-called permanent power, so long as the river will furnish it, is sold at a daily rate, and charged for only when used, the present rate per mill power for a twelve-hour day or night being \$2.50 net.

In addition to the permanent and surplus power already named there has been sold certain power designated as "non-permanent power," which is not guaranteed, but will be furnished when there is more than a sufficient quantity in the river to supply all the permanent power, together with 50 per cent. of it as surplus. The rate of charge for non-permanent power is a bonus of \$4,500 per mill power and an annual rental of \$1,500, with a rebate of the entire rent during times of non-supply.

By chapter 152 of the Acts of 1909 the Holyoke Water Power Company was authorized to generate electricity for power and lighting purposes. Two water wheel units of 2,085 horsepower combined capacity, and steam turbines with a total rated capacity of 1,750 kilowatts, are installed in their power station located between the second level canal and the river.

The Holyoke municipal electric plant also has four water wheels of 1,120 horsepower combined capacity, together with engines rated at 13,561 horsepower. These two installations are the only ones at Holyoke in which hydro-electric power is generated for sale.

Water Power at Turners Falls.

The recent redevelopment at Turners Falls represents the modern form of hydro-electric developments in contrast to the methods employed in the middle of the nineteenth century, when the systems on the Merrimack at Lawrence and Lowell, and on the Connecticut at Holyoke, and the earlier development at Turners Falls were laid out. The following information regarding the development at Turners Falls is taken from Professor Porter's report in the 1880 census, and from a description of the redevelopment furnished by Mr. Howard M. Turner, hydraulic engineer of the Turners Falls Power and Electric Company.

The "Proprietors of the Locks and Canals on the Connecticut River" was incorporated in 1792 for the purpose of rendering the Connecticut River passable from the mouth of the Chicopee River northward. In 1794 this corporation was formed into two separate corporations, one bearing the old title and the other known as the "Proprietors of the Upper Locks and Canals." The former built the dam and canals at Holyoke, while the latter improved the river at Turners Falls. The dams and canal at this point were completed in 1798. After the construction of railroads on the banks of the Connecticut River the works of the Canal Company were in disuse until 1866, when the privilege was developed for water power and the name of the company changed to the "Turners Falls Company." A timber dam was put across the river, and a bulkhead equipped with head gates and a canal about 3,000 feet long were constructed on the Turners Falls side with mills located between the canal and the river. This dam was in two sections each about 500 feet long and about 30 feet high, running from either shore to a rocky island in the middle of the river.

The canal was confined to one level extending about 3,000 feet approximately parallel to the river and at a distance from it varying from 100 to 250 feet in the main part of its course, but increasing to 500 or 600 feet toward the end. It had an average width of 50 feet and a water depth of 11 feet. The fall varied from 29 feet at the mills at the upper end of the canal to 40 feet at the lower end. The water was leased to the mills under permanent indentures. The mills now leasing it in this way, together with the quantities allowed by their leases and the size of their water wheel installations, are shown in Table No. X., on page 70.

In 1904-07, with the development of the electrical power business, the company extended the canal a distance of 275 feet parallel to the river. At this point a right-angle turn was made and the canal extended 700 feet to an hydro-electric power station of about 7,000 horsepower ultimate capacity, located on the river bank down-stream from the mills. This power house contains four large units of pairs of horizontal wheels in steel cases at the end of steel penstocks 97 feet long leading from the canal. Branch penstocks supply water to

three smaller single horizontal wheels. All the wheels are direct connected to horizontal generators. In connection with this work the canal, for a distance of 300 feet just below the head gates, was enlarged to 130 feet wide, the depth being 11 feet as in the original canal. A new head-gate building with eight gates, 8 by 10 feet, was built on the shore at one side of the original head-gate structure.

With the expansion of the electric power business more capacity became necessary, and in 1912 work was started on the extension of the canal to Montague City, approximately a mile and a half down-stream, and the installation of a new plant at that point, using very much more water and operating under a head of from 54 to 58 feet. This work necessitated the widening and deepening of the original canal to 128 feet wide by 18 feet deep; the excavation of a canal 4,000 feet long, 25 feet deep, and with an average width of 130 feet; the construction of embankments around the forebay pond of an average height of 14 feet, and a length of about 3,800 feet on each side of the canal; the excavation of another section of canal 850 feet long, 25 feet deep and 150 feet wide to the new power house, which was built for an ultimate capacity of six units, four of which have been installed. These units consist of a single vertical runner 114 inches in diameter in concrete scroll case with concrete penstocks from the canal built up in the foundation of the power house. Generators of 8,000 K. V. A. capacity are set above the wheels, and the rotating parts carried by thrust bearings set on top of the generators. The current is generated at 2,300 volts in the first power station, and at 6,600 volts in Station No. 2. It is stepped up to 66,000 volts for transmission through the company's main lines, though a part is raised to only 13,200 volts for local distribution.

In connection with this work a new dam was built at Turners Falls below the old timber crib dam. This dam is of concrete, 3 feet higher than the previous dam, the crest being at elevation 103,¹ which is the same as the elevation of the top of the canal wall. The portion on the Turners Falls side of the island is built close below the timber dam; that on the other side of

¹ Elevations refer to Turners Falls Power Company datum based on assuming crest of old dam at elevation 100. Add 68.894 feet to refer elevations to Hartford United States Zero (approximately low water as determined by Ellis, 1872-78).

the island, 250 feet down-stream. A part of the island on each side has been removed to give more spillway length during freshets. Each half of the dam has six flood gates approximately 7 by 8 feet, operated from a tunnel in the dam. Nine new head gates $8\frac{1}{2}$ feet wide and 12 feet in length were also put in to take the place of the original ones built in 1866.

The level of the water in the canal determines the head acting on the wheels at the mills and the power stations, the water being carried at a constant level in the canal inside the head gates. At present the water there is maintained at elevation 101, or 2 feet below the top of the canal walls.

In 1912 the Turners Falls Power and Electric Company acquired the rights of the French King Rapids Power Company, controlling the fall in the river at French King just above the mouth of the Millers River. The acquisition of this right enabled the company to carry flashboards on the new dam to a height of $4\frac{1}{2}$ feet, or to elevation 107.5. The extreme range from top of flashboards to low water in the river opposite the new power station is about 68 feet.

The details regarding the installations at the two hydro-electric stations are shown in Tables XI. and XII., respectively, on page 71.

During May, 1916, at which time there was plenty of water in the river, the average daily use of water at the mills shown in Table X., page 70, amounted to 1,747 second-feet; at the hydro-electric plant No. 1, shown by Table XI., page 71, 714 second-feet; and at the new hydro-electric plant, No. 2, shown by Table XII., page 71, 1,936 second-feet; or a total of 4,397 second-feet. In every case the figures are on a twenty-four-hour basis and for working days, as only a small amount of water is used on Sundays and holidays, but at that time only three of the units in the new power plant had been installed. The areas and capacities of the pond from 1 foot below the crest of the dam, elevation 102 Turners Falls Power Company datum, to 5 feet above the crest of the dam, or elevation 108, are given in Table XIII., on page 72.

The total pondage available is nearly 275,000,000 cubic feet, which is in excess of that available at Lowell, and is sufficient to equalize the daily flow and also to hold back the Sunday flow during the dry season.

When full to elevation 107.5 the pond extends above the State line. From the top of the flashboards at Turners Falls to tail-water at the Connecticut River Power Company's plant at Vernon, some $5\frac{1}{2}$ miles above the State line, there is a rise of about 7 feet, the Vernon tail-water being at elevation 114.8 referred to the Turners Falls Company's datum.

Storage on the Connecticut River Basin.

But little information regarding storage on the Connecticut River outside of the State of Massachusetts has been obtained to date. Within this State there are small amounts on the Chicopee, Millers and Westfield rivers, but these are all too small to materially affect the flow of the Connecticut River. At the headwaters of the Deerfield River at Somerset, Vt., a large reservoir was built in 1912 by the New England Power Company, which has a storage capacity of 2,675,000,000 cubic feet, and completely controls the run-off of 30.2 square miles. The company states that this storage will maintain a flow of 400 second-feet at Station No. 5 (Monroe Bridge) during low water of an average year.

The possibilities of storage in the Connecticut lakes at the headwaters of the Connecticut River have been investigated by private companies, and it is understood that a considerable amount of storage can be obtained in these lakes, a part of which is already in use. However, to develop this storage on a commercial basis and secure its equitable distribution would require the co-operation of all the interests affected, and probably the assistance of legislative action on the part of the States of Vermont, New Hampshire, Massachusetts and Connecticut.

The increase of storage on the tributaries of the Connecticut in the State of Massachusetts is considered more fully in other parts of this report.

While it is apparent that further storage cannot be created on the Connecticut River within the State of Massachusetts, inasmuch as the pondage capacity of the river above the dams at Holyoke and Turners Falls is fully utilized, it should be possible to use water now wasted at Holyoke either by the installation of secondary units to replace steam power, or by the extension of the hours of operation of existing plants.

TABLE X. — *Turners Falls Power and Electric Company.*
Mills along Canal, Turners Falls.

Leases.	HEAD.		Horse-power of Wheels at 100 Per Cent. Gate.	LEASED POWER.			Hours Power is used per Day.	Hours' Use allowed by Lease.
	Gross Head (Feet).	Net Effective Head on Wheel (Feet).		Per-manent.	Surplus.	Total.		
International Paper Company, ...	33	32.6	5,235	824 ¹ 3,000 ²	413 ¹ 1,500 ²	1,237 ¹ 4,500 ²	24	24
John Russell Cutlery Company, ...	{ 32.1 32.6	{ 31.8 31.2	{ 908	{ 156 ¹ 675 ²	{ — —	{ 156 ¹ 675 ²	{ 9	{ 16
Keith Paper Company, ...	{ 38.8 37.5	{ 38.1 35.5	{ 1,760	{ 289 ¹ 1,279 ²	{ 78 ¹ 324 ²	{ 364 ¹ 1,613 ²	{ 24	{ 24
Ealeck Manufacturing Company, ...	40.3	39.6	778	— —	113 ¹ 500 ²	113 ¹ 500 ²	24	24
Turners Falls Cotton Mill, ...	28.8	28.2	473	176 ¹ 500 ²	— —	176 ¹ 500 ²	9	16

¹ Water, cubic feet per second.

² Theoretical horsepower.

Wheels are set in steel cases at the end of steel penstocks leading from canal which is adjacent to mill property.

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TABLE XI. — *Turners Falls Power and Electric Company.**Hydro-electric Plant No. 1, Turners Falls.*

[Located on branch from main canal below mills.]

UNIT NUMBER.	HEAD.		Horsepower of Wheels.	Capacity of Generator (K. W.).
	Gross Average Head (Feet).	Net Head on Wheel (Feet).		
1.	40.3	38.8	2,060 ¹	1,500
2.	40.3	38.8	540 ¹	250 ²
3.	40.3	38.8	1,690 ¹	400 ²
4.	40.3	38.8	150 ¹	1,250
5.	40.3	38.8	1,169	75
6.	40.3	38.8	540 ¹	1,000
7.	40.3	38.8	1,320	400
Total, ...	—	—	7,469	1,000
				5,875

¹ Manufacturer's rating.² Direct current.³ Alternating current.

Units Nos. 1, 3, 5 and 7 consist of a pair of horizontal wheels with separate draft tubes in steel cases at the end of steel penstocks 18 feet in diameter, leading from the canal a distance of 97 feet.

Units Nos. 2, 4 and 6 are single horizontal wheels on branch penstocks leading from the four large penstocks.

TABLE XII. — *Turners Falls Power and Electric Company.**Hydro-electric Plant No. 2, Montague City.*

[Located at end of canal below forebay pond.]

UNIT NUMBER.	HEAD.		Horsepower of Wheels.	Capacity of Generator (K. V. A.).
	Average Gross Head (Feet).	Net Head on Wheel.		
1.	56	55.2	10,000	8,000
2.	56	55.2	10,000	8,000
3.	56	55.2	10,000	8,000
4.	56	55.2	10,000	8,000
Total, ...	—	—	40,000	32,000

Provision made for two more units, 5 and 6, of same size as above.

Installation consists of single vertical wheels in concrete scroll case with concrete draft tube. Concrete penstocks divided in three parts by partition walls built into power-house foundation carry the water from the racks at the canal to the wheels, a distance of 66 feet. Revolving parts suspended from thrust bearing on top of generator.

TABLE XIII. — *Turners Falls Power and Electric Company.*

[Area and capacity of pond above dam.]

Elevation.	HEIGHT ON DAM.	Area (Square Feet).	Capacity above Elevation 102 (Cubic Feet).
102, . . .	1 foot below crest of present dam, ...	16,380,000	-
103, . . .	Crest of dam, ...	12,747,000	17,563,000
104, . . .	1 foot above crest, ...	38,814,000	45,344,000
105, . . .	2 feet above crest, ...	46,840,000	87,170,000
106, . . .	3 feet above crest, ...	59,271,000	140,225,000
107, . . .	4 feet above crest, ...	67,282,000	203,501,000
108, . . .	5 feet above crest, ...	73,261,000	273,772,000

The figures given in this table are approximate.

MILLERS RIVER.

The Millers River is the smallest of the four main tributaries of the Connecticut River in the State of Massachusetts. It might be said to be formed at Whitney Pond in Winchendon by the union of two branches, one being the outlet of Lake Monomonac, and the other coming from Ashburnham. From thence it flows in a generally westerly direction to the Connecticut River, a distance of 36 miles, passing through South Royalston, Athol, Orange, Erving and Millers Falls, and entering the Connecticut River above the Turners Falls Power and Electric Company's power development at Montague City. The total drainage area is 394 square miles.

Below Winchendon the river is joined by the following streams from the north, in the order named:—

BRANCH.	Drainage Area (Square Miles).
Harriaville, ...	26.8
Priest Brook, ...	22.6
Tully River, ...	74.1
Moss Brook, ...	12.5

The two main tributaries from the south are Otter River, 59.2 square miles, and the Eagleville Branch, 20.0 square miles.

In general, the watershed is compact and relatively flat, with considerable natural storage together with many favorable opportunities for increasing it. Outside of the towns along the course of the river the land is largely unimproved, the soil being sandy and not particularly adapted to farming purposes.

The following table shows the principal cities and towns on the watershed, with their population according to the 1915 census: —

NAME.	Population in 1915.
Montague, ...	7,925
Erving, ...	1,168
Wendell, ...	338
Orange, ...	5,379
Warwick, ...	477
Royalston, ...	862
Athol, ...	9,788
Templeton, ...	4,061
Gardner, ...	16,376
Winchendon, ...	5,908

The principal industries are engaged in the manufacture of furniture and machine tools, but in addition to these there are three paper mills, a woolen mill and several small miscellaneous mills. Of the cities and towns within the watershed, Montague, Gardner, Winchendon, Athol and Orange have public water supplies. Winchendon and Orange are supplied from wells, whereas Gardner and Athol have surface water supplies with small drainage areas of 3.54 and 1.68 square miles, respectively. Montague is supplied from Lake Pleasant, which is outside of the Millers River drainage basin. The water-supply systems are small and unimportant as compared with the total drainage area. The population of the towns in this watershed is so small that the supply of water required for municipal purposes and manufacturing industries is not a serious problem.

The slope of the river and its tributaries is so flat that damaging floods are unknown, and the rise of the river in even the most severe freshets is only moderate. At South Royalston, where the drainage area is 187 square miles, the river rarely rises more than 3 feet on F. N. Farrar's dam, which is 212 feet long.

The mean annual precipitation in the basin is about 40 inches.

Developed Water Power.

Table XIV. (A), on pages 92 to 95, shows the water power developed on the Millers River. The total head developed on the main river between Millers Falls and Winchendon is 333 feet, but one privilege of 15 feet is not in use at the present time. On the remaining 318 feet of fall there is an installed water wheel capacity of 7,450 horsepower, in addition to which there is about 2,000 horsepower on the tributaries of the main river. Of this 7,450 horsepower, 4,526 horsepower is used on twenty-four-hour power, and 2,924 horsepower on ten-hour power. Three privileges develop electric power for sale, — the lowest is at Farley, where 15 feet of head is utilized by a plant owned by the Franklin County Power Company, but operated by and in connection with the Athol Gas and Electric Company's system; the Athol Gas and Electric Company also have a privilege at Wendell depot, where 21 feet of head is obtained; and the third privilege is that of the Winchendon Electric Light and Power Company below Winchendon, where 23 feet of head is utilized.

The entire watershed is well supplied with electric transmission lines. At the lower end the Franklin Electric Light Company, which sells power in Millers Falls, is connected with and is a part of the Turners Falls Power System. The lines of the Athol Gas and Electric Company run from Farley, a short distance above Millers Falls, and from Wendell through Orange to Athol and from there to Gardner, where they are connected with a line of the Connecticut River Transmission Company. The main transmission line, from the Vernon plant on the Connecticut River to Fitchburg, passes near Winchendon, where it is connected with the system of the Winchendon Electric Light and Power Company. The Northern Massachusetts

Street Railway Company, which operates in Orange, Athol, Templeton, Winchendon, Gardner, Westminster and Fitchburg, buys power from the Athol Gas and Electric Company, and the Templeton, Ashburnham and Princeton municipal plants obtain their power largely from the Gardner Electric Light Company, which is affiliated with the Connecticut River Transmission Company.

Undeveloped Power.

The undeveloped power on the main river is located in three stretches. The lowest extends from the mill pond of the Millers Falls Paper Company at Millers Falls to the tail-race of the Washburn & Heywood Chair Company at Erving, between which there is a gross head of 159 feet of which but 15 feet are in use, this being at Farley at the Athol Gas and Electric Company's privilege mentioned above. Plans have been made for the development of this power by means of a long canal. It was estimated that a net head of about 154 feet could be obtained warranting an installation of generators totaling 10,000 K.W. Applying the ratio ordinarily desired between the size of generators and water wheels this would mean water wheels of from 15,000 to 16,000 horsepower capacity. The watershed is about 374 square miles. If this undeveloped power is put on the basis of the mean annual flow of the river, as was done in the case of the Westfield River, this privilege would call for an installation of 8,750 horsepower. This is assuming that the mean annual flow of the Millers River is 1.67 second-feet per square mile, but no long-term records of the flow of Millers River exist, and this assumption of 1.67 second-feet is simply a preliminary estimate based largely on the flow of the South Branch of the Nashua River above Clinton.

The next stretch of undeveloped power is between Athol and South Royalston, where there is an undeveloped head of 230 feet which has also been surveyed by interested parties who made plans to develop it by means of two dams and canals. The drainage area at the upper dam site is 187 square miles. It was estimated that 9,600 K.W. could be installed at the two plants with a total net head of about 217 feet, but an installation developing the mean flow at the same head would produce only 6,160 horsepower.

The third privilege is owned by Mr. William M. Whitney, and is located below Winchendon at Hydeville. Plans were made for the development of this power by a canal running from what was formerly the Winchendon Spool and Bobbin Company's privilege at Waterville across a bend in the river. From the canal penstocks were planned to extend to a power house located on the river. A gross head of about 49 feet was to be obtained, for which an installation of generators of 600 K.W. was contemplated. This 49 feet included the privilege formerly belonging to the Winchendon Spool and Bobbin Company with a head of 10 feet. The drainage area is 55 square miles. One of the reservoir sites surveyed during the summer of 1916 is located just below this privilege, and would include it. If the dam were constructed below in order to create the reservoir proposed, the head obtainable would be about 5 feet less, but the drainage area would be increased to 85 square miles.

In addition to the power developed by these three privileges on the main river, a certain amount of power could also be obtained at some of the contemplated storage reservoirs. The largest power could be developed in connection with the proposed Tully Reservoir, where a head ranging from 140 feet with a full reservoir to 80 feet when it is drawn down can be had by a penstock about $1\frac{1}{4}$ miles long extending down to Fryville. The following table summarizes these four undeveloped privileges, the power estimates being on the basis of the assumed mean flow of the river of 1.67 second-feet per square mile.

Undeveloped Power on Millers River.

LOCATION.	Drainage Area (Acres).	Average Net Head assumed.	Horsepower based on 1.67 Second-feet per Square Mile.
Millers Falls to Erving, ...	374	154	8,750
Athol to South Royalston, ...	187	217	6,160
Hydeville, ...	85	40	516
Proposed Tully Reservoir, ...	50	110	835
Total, ...	-	-	16,261

Storage now in Use.

There is a certain amount of storage at present in use on the Millers River. In every case this is owned and controlled by the mill that is located either directly at the dam or a short distance below it, and the cost is borne by this mill which operates the storage as it sees fit and receives the greatest benefit therefrom.

Table XV., on pages 96 to 98, gives the principal lakes and ponds of the Millers River Basin, with information regarding this existing storage. All told, 57 square miles of drainage area are in part controlled by this storage at present in use. The most important of these reservoirs are Monomonac Lake, with a storage of 250,000,000 cubic feet, and a drainage area of 18.9 square miles, controlled by the Nelson D. White & Sons cotton mills at its outlet; Upper and Lower Naukeag Reservoirs in Ashburnham, with a storage capacity of 50,000,000 and 70,000,000 cubic feet, respectively, controlled by William M. Whitney and held for the benefit of mills in Winchendon; Eagleville Reservoir, in the town of Athol, with about 34,000,000 cubic feet of storage and 20 square miles of drainage area, controlled by the Rodney Hunt Machine Company, who has a small hydro-electric development at its foot from which electricity is transmitted to its mill in Orange.

The tendency on Millers River, as well as in other parts of the State and country, has been towards the abandonment of the small mills on the smaller branches of the river. Most of these had mill ponds, some were natural ponds of considerable size, and all told they may have had considerable effect in regulating the flow of the river. A great many of these mill ponds on the Millers River have been abandoned, and as time has passed the dams have gone out and the streams now flow through the middle of the ponds which have filled with a growth of grass and small brush.

In 1911 a number of the mill owners on the Millers River, including Baxter D. Whitney & Son in Winchendon, L. S. Starrett & Co. in Athol, and others, became interested in the storage question, and had investigations made by Fowler &

Toquet of Springfield and also by Mr. Safford of Lowell. The matter was later taken up by an organization known as the Millers River Improvement Company of which Mr. Fred T. Ley of Springfield was a leading factor. During the summer of 1912 extensive surveys were made of five reservoir sites on tributaries, in addition to the Birch Hill site on the main river above South Royalston. Copies of these surveys, together with estimates of their cost, have been furnished us by Mr. Fowler of Fowler & Toquet, and are described on pages 79 to 82.

After these surveys and plans had been made, a bill was introduced into the Legislature of 1913 asking for a charter for the Improvement Company. The bill as introduced provided for the assessment of the cost of a system of reservoirs upon the users of water power benefiting from the stored water, with the general supervision of the assessments by a State commission. The bill was opposed by a large number of the owners of water power throughout the State, it being held that conditions were too uncertain, and that any such policy if undertaken by the State for the Millers River might have unforeseen and undesirable results upon other streams. For these reasons the bill was rejected by the General Court.

The previous work done on the Millers River has been reviewed by the engineers of the Commission, and additional surveys made. There are eight reservoir possibilities which appear worthy of consideration in addition to Lake Monomonac, which already has a storage capacity of 250,000,000 cubic feet. The following table gives the names, areas and estimated storage capacity of these proposed reservoirs, and the accompanying plate, "Millers River Watershed," shows the location of these reservoir sites: —

Table of Proposed Reservoirs.

RESERVOIRS.	Gross Drainage Area (Square Miles).	Approx- imate Eleva- tion of Spillway above Mean Sea Level (Feet).	Height of Spillway above Present Water Surface (Feet).	Area of Res- ervoir (Acres).	Proposed Ad- ditional Storage Capacity (Million Cubic Feet).	Existing Storage Capacity (Million Cubic Feet).
Moss Brook, ...	11.6	666	40	708	536	-
West Tully, ...	15.4	605	55	480	545	-
Tully, ...	50.0	710	74	1,670	2,428	-
Priest Brook, ...	18.5	890	57	910	1,020	-
Sp Pond, ...	19.8	850	28	796	492	-
Hydeville, ...	84.0	873	44	802	346	-
Gardner, ...	19.0	955	39	910	800	-
Lake Monomonic, ...	18.9	-	-	644	-	250
Naukeag and Whitmore Brook, ...	18.6	-	6 ¹	918	246	68
Upper Naukeag, ...	2.0	-	-	-	-	50
Totals, ...	-	-	-	7,835	6,413	398

¹ Above present water surface of Lower Naukeag Reservoir.

The first five reservoirs of this table were surveyed by the Millers River Improvement Company. The Hydeville and Gardner projects have been investigated by the engineers of this Commission, while a report on the Naukeag and Whitmore Brook Reservoir was made in 1905 for Baxter D. Whitney & Son. Below is given the description of these various sites.

Priest Brook.—The proposed Priest Brook Reservoir is in the towns of Royalston and Winchendon. The dam site is located a short distance south of the highway running from Winchendon to Royalston, and the reservoir site extends north some 3 miles, with the upper end in New Hampshire. A dam nearly 2,000 feet long was proposed, having a height of 62 feet above the water level of the brook, with a spillway 5 feet lower. The reservoir would flow 910 acres and have a capacity of 1,020,000,000 cubic feet. The drainage area above the dam site is 18.5 square miles. The area that would be flooded is sparsely covered with timber, with considerable stretches of swamp grass along the stream. The soil is sandy, and there is no cultivated land within the basin to

be flooded, although one or two farmhouses would be affected. In the estimates made by the Millers River Improvement Company the land was valued at \$40 per acre including damage to buildings, which probably was a fair assumption, as they had obtained options for a considerable amount of the areas which they proposed to flood, and \$40 per acre is much more than the land would be worth for any other purpose. No ledge appears at the dam site, the surface soil being sandy as in the rest of the basin, but rock may be located at a considerable distance below the surface, which may increase the cost considerably above that estimated.

Sip Pond. — The second site, called the Sip Pond Reservoir, is in Winchendon, Mass., and Fitzwilliam and Rindge, N. H. The dam site is located at Harrisville in Winchendon, while most of the land flowed would be in New Hampshire, and would include Sip Pond and also a long narrow pond a mile and a half east of Sip Pond. This would flood the Cheshire Branch of the Boston & Maine Railroad for a distance of nearly 2 miles, together with the State line station on this road. It was estimated that the cost of raising the railroad would be \$93,000, or nearly half the total cost of the reservoir.

A dam 860 feet long, but of only 33 feet maximum height, together with a dike 780 feet long, would be required which would flow 796 acres and give a storage of 492,000,000 cubic feet. The drainage area is nearly 20 square miles. The greater part of the reservoir site is swamp land, although there is some poor farming land, and several houses would be affected.

At the foot of the long narrow pond mentioned above there are two small water-power privileges belonging to the Jonas Damon Estate, which are used in connection with two sawmills. The heads developed are between 11 and 12 feet at each mill. At the lower mill a 48-inch Rodney Hunt wheel rated at 60 horsepower is installed, while there are four wheels aggregating 90 horsepower at the upper mill. The Millers River Improvement Company had options on this property. They estimated the cost of land at \$60 per acre, which amounted to nearly \$50,000 for the entire basin. Nearly 3 miles of highway changes would be required. As in the case of Priest Brook, no ledge was visible at this site, but the size of the dam is too small to

make it in any way a serious problem. The worst feature of this reservoir is the raising of the railroad and changing of the State line station, and furthermore, the fact that the basin would be so largely in New Hampshire might complicate the situation.

Moss Brook. — The Moss Brook dam site is located in the town of Warwick, a mile and a half north of Wendell depot. This is an excellent dam site with ledge showing on both sides of the valley and along the stream, and a dam 45 feet high and 480 feet long could be built flowing 705 acres and giving a storage of 536,000,000 cubic feet which would control a drainage area of 11.6 square miles. The basin flowed is swamp land with a small amount of poor farming land. But few houses would be affected, and the roads which would have to be changed are unimportant dirt roads which could be relocated to good advantage.

The property costs are estimated at \$41,525, of which it was figured \$10,000 could be saved in salvage. Land valued at \$29,525 in the estimate had either been purchased or was under option, but it is understood that the land has since been sold and the options allowed to lapse.

Tully River. — The Tully River Reservoir was the largest and most important proposed by the Improvement Company. It was planned to construct an earth dam 81 feet high and 2,840 feet long, flooding an area of 1,670 acres, or over 2½ square miles, with nearly 2,500,000,000 cubic feet of storage, which was about one-half of the total storage of the five proposed reservoirs.

The reservoir site is almost entirely timber land that has been largely cut over, although it includes a small amount of poor farming land and is crossed by the steel tower transmission line of the Connecticut River Transmission Company; but aside from this and the roads which would have to be relocated the damage done is relatively small. The drainage area is 50 square miles, so that a reservoir of this capacity could exercise a considerable influence on the flow of the river below.

There are two small water-power privileges at Fryville, a short distance below the proposed dam, where heads of 22 and 11 feet were formerly in use. A pipe line about 1¼ miles long

from the proposed dam to the lower privilege would afford a head of 144 feet with a full reservoir, or an average head of 110 feet, on which 835 horsepower could be installed assuming an installation up to the mean flow of the river.

West Tully Brook. — This site is located on the west branch of Tully River northwest of Tully Mountain, and is the least desirable of the five sites surveyed by the Millers River Improvement Company. The drainage area is 15.4 square miles. The survey showed that a 60-foot dam would flow 480 acres and give a storage of 545,000,000 cubic feet. In the case of this reservoir the greater part of the cost was in the construction of the dam, which had a total length of 1,700 feet. The reservoir site is largely timber land, although there is some fairly good meadow land in the middle of it, and the value was estimated at \$60 per acre.

Of the five reservoir sites described above, that on Tully River is by far the best, while Moss Brook and Priest Brook follow in the order named. Sip Pond would be good were it not for flooding the railroad and the sawmills. It is possible that a good part of the benefit expected from the Sip Pond Reservoir can be obtained by the proposed Hydeville Reservoir, which is described on page 84.

Naukeag and Whitmore Brook Basin. — This reservoir site is located on the branch of the Millers River, which flows from Naukeag down to the Whitney Pond at Winchendon. In 1905 this project was investigated for Baxter D. Whitney & Son by Charles T. Main. A copy of his report and blueprints of the surveys were furnished us.

At the present time Upper and Lower Naukeag reservoirs are used for storage with 50,000,000 and 70,000,000 cubic feet of capacity, respectively. Lower Naukeag has an area of 280 acres, which is controlled to a depth of 6 or 7 feet. The outlet of Lower Naukeag is joined by Whitmore Brook a short distance below the reservoir, and the plan provided for two dams just above this point, one on Whitmore Brook and the other on the outlet of Lower Naukeag. The water surface of the proposed reservoir was to be 6 feet above the present water level of Lower Naukeag, and the two ponds thus formed would be joined through a depression in the watershed divide be-

tween them. The entire area of the reservoir would be about 900 acres, and the storage obtainable was estimated at 390,000,000 cubic feet or 270,000,000 cubic feet more than the present available storage. The estimated cost, which does not include the value of the land flowed, was \$60,700, or \$225 per million cubic feet. The land is largely owned by Mr. Whitney, but some highway relocation and raising would be required, and there is one summer camp on Lower Naukeag which would have to be moved.

Lake Monomonac. — Lake Monomonac is on the other branch of the Millers River above the Whitney Pond in Winchendon, and has a drainage area of 18.9 square miles. At the present time a storage of 250,000,000 cubic feet is obtained by means of a 13-foot dam located at the outlet of the lake, which is controlled by Nelson D. White & Sons who have two mills a short distance below the dam at each of which there is a head of 21 feet. If this dam had been raised 10 feet it would have flowed a very much larger area and given a total storage of 827,000,000 cubic feet. The present storage, however, is sufficient to make an almost complete use of the run-off, as it appears that for the last five years all the water has been used with the exception of the spring of 1916, when the lake was drawn down to make room for the large accumulation of snow on the ground at that time. As is almost always the case with water powers located on small drainage areas, the water-wheel installation is very large compared with the size of the watershed, and a relatively small amount of storage controls the flood flows sufficiently to make the entire flow available.

The water from Lake Monomonac is drawn on steadily through the spring and summer until the lake has been drawn down nearly if not quite all of the 13 feet available. To raise the lake 10 feet would not require very extensive dams, but there are a number of summer cottages on the shores of the lake, and two roads that would have to be raised, one of which is a State highway, so that it is possible that the benefits obtained would not be commensurate with the cost. The upper half of the lake is in the State of New Hampshire.

Hydeville Reservoir.

The proposed Hydeville Reservoir is located on the Millers River about 2½ miles below Whitney Pond, in Winchendon. The dam site is about .6 of a mile below the Hydeville Bridge. It is proposed to build an earth dam 55 feet high with spillway at elevation 873, which will raise the present water level 10 feet. This would create a reservoir of 802 acres, flooding part of the old bobbin mill privilege on the Millers River at Waterville, and up nearly to Harrisville on the Sip Pond Branch of the river, entirely covering the pond and settlement at Harrisville. The principal part of the main dam would be at least 500 feet long. In addition, it would be necessary to construct a concrete spillway, 250 feet long and of about 17 feet maximum height, some 2,500 feet northwest of the main dam, where a depression occurs from which there is a natural channel leading back to the river, which it enters a quarter of a mile or so below the site of the main dam. A general plan of this development is shown on the accompanying plate. In connection with the dam a small hydro-electric power station is planned with four units of 600 horsepower each on a 40-foot head, with a generating capacity of 400 K. W. capacity, each directly connected.

In operation the plan would be to use this reservoir as a regulating basin on the river, using it both for storage and for power. Storage amounting to 346,000,000 cubic feet would be available in the top 13 feet of the reservoir, while the head for power development would vary from 44 feet at full pond to 10 feet at low water.

Plans were made for the development of the upper part of this privilege for power by Mr. William M. Whitney of Winchendon about 1910. It was proposed at that time to take in only the main Millers River from Winchendon without the Sip Pond Branch, by the construction of a low dam at the old bobbin mill privilege, diverting the water in a canal from which penstocks were to carry it to a power station on the river located either near the Hydeville Bridge or, according to an alternative plan, some distance below this bridge. A head of 40 feet can be obtained in this way, or 5 feet higher than that by the plan here proposed. The drainage area would be only 51



square miles instead of 84, and the pondage would be limited to 3,000,000 cubic feet.

If the proposed system of reservoirs in the Millers River should be constructed, this storage of 346,000,000 cubic feet at the Hydeville Reservoir would prove to be of the greatest advantage in giving proper regulation of flow.

Gardner Reservoir.

The proposed Gardner Reservoir is located on the Otter River Branch of the Millers River, in the towns of Gardner, Templeton and Hubbardston. The dam site is located near Kendall Pond, about one-half mile south of West Broadway, which is the road connecting Gardner and East Templeton. The drainage area at this point is 19 square miles.

This site was also surveyed by the engineers of the Commission during the fall of 1916. It is proposed to build an earth dam 36 feet high, raising the present water level 39 feet, flowing 910 acres at the spillway level and storing 794,000,000 cubic feet in the top 30 feet. The land which would be flowed by the reservoir is largely swamp land, a considerable part of which is covered with pine and hemlock. There are five houses which would be affected, two of which are only small one-room dwellings. The other three are two-story houses near the flow line, located near a pail factory using a small amount of water power, which would also be destroyed by the reservoir.

The highway extending from Partridgeville to South Gardner crosses the central part of the proposed basin. This is a side road and not very important. It is planned to replace it by a road running from the Partridgeville end, crossing the proposed dam and joining West Broadway.

An earth dam with clay puddle core is proposed, the top to be at elevation 962. The elevation of the swamp where it is crossed by the dam is about 916, which makes the maximum height of the earth embankment 46 feet above the present ground surface. The total length of the dam would be about 2,500 feet, of which about 800 feet would be of nearly maximum height.

Cost of Proposed Reservoirs.

It is impossible to give wholly satisfactory estimates of cost of these proposed reservoirs at the present time, with the present inflated and rapidly shifting prices. No estimate could be made which would hold good a month later. However, it can be safely assumed that no project such as is here proposed would be undertaken until conditions had become more settled; therefore in making up the estimates unit prices have been assumed that roughly correspond to those existing previous to 1914. There is also a great deal of uncertainty in regard to the foundation conditions at the reservoir sites, and in every case it has been necessary to make assumptions based upon surface appearances. Considering these facts, the estimates of cost are at best only approximate, but it has been thought desirable to give definite figures, both for the cost and benefits of the system, in order to show the size of the projects, and also the degree of improvement in the flow of the river to be expected.

Estimates for the reservoirs surveyed by the Millers River Improvement Company were made by their engineers and submitted to the legislative committee at the time the hearings were held in 1913. The values of land assumed in these estimates were based largely upon actual purchase or options actually held by the Improvement Company at that time. These estimates have been carefully reviewed, and, excepting where it has seemed desirable to make minor changes, 25 per cent, has been added to the cost to allow for the uncertainty of foundation conditions. The following table shows the estimated cost of each of the proposed reservoirs:—

Estimated Cost of Millers River Reservoirs.

RESERVOIR.	Gross Drainage Area (Square Miles).	Area of Reservoir (Acres).	Storage Capacity (Million Cubic Feet).	Cost.	Cost per Million Cubic Feet.
Moss Brook, ...	11.6	705	536	\$186,062	\$254
Tully, ...	50.0	1,670	2,428	370,656	153
West Tully, ...	15.4	480	545	274,674	504
Priest Brook, ...	18.5	910	1,020	374,312	366
Sip Pond, ...	19.8	796	492	277,690	564
Hydeville, ...	84.0 ¹	802	346	330,000 ²	954 ³
Gardner, ...	19.0	910	800	425,000	535
Lower Naukeag and Whitmore Brook, ...	18.6	918	246 ³	88,000	328
Total, ...	198.5	7,191	6,412	\$2,276,384	—
Average cost of reservoir, ...	—	—	—	—	\$354

¹ Includes Sip Pond and Lower Naukeag and Whitmore Brook.

² Includes cost of 800 K. W. power development.

³ In addition to 68,000,000 cubic feet at present.

The total cost of the eight reservoirs amounts to nearly \$2,300,000, or \$354 per million cubic feet. The cost of the individual reservoirs varies from \$153 per million cubic feet for the Tully Reservoir to \$564 per million cubic feet for the one at Sip Pond. The proposed Hydeville Reservoir shows a cost of \$954 per million cubic feet, but this includes the cost of the 800 K.W. power development. Considering the value of this power, and the extreme importance of having pondage at this point in the river, it appears that this reservoir should form a part of the complete system.

It has been assumed that the annual cost of this system of reservoirs, including interest, maintenance and operation, would amount to 10 per cent. of the initial cost, or about \$230,000 a year.

Benefits resulting from Reservoirs.

It is extremely difficult to make satisfactory estimates of the benefit resulting from this proposed system of reservoirs without more complete information than is available. However, as in the case of the cost of the reservoirs, definite figures, even though approximate, are considered preferable to no figures at all:

A system of reservoirs can be operated according to one of two methods. The first method is to have the storage so manipulated as to produce a maximum amount of primary power, that is to say, power available at all times. If operated in this manner the reservoirs must be kept filled a large part of the time in order to have the water available for use during exceptionally dry periods.

The second method is to make a complete use of the water power. Under this method all the water which collects during the winter and spring months will be let down during the summer, in wet summers producing an abnormally high flow, while in case a dry period occurs during the late fall and early winter, the storage has been completely used and only the natural flow of the river remains.

A compromise between these two methods has been used. In general, a flow of about 1.25 second-feet per square mile has been maintained at four chosen locations on the river, this flow being maintained until certain depletion has occurred in the reservoirs, when the rate has been lowered to an amount which can be maintained constantly.

Since run-off records for the Millers River have been available since 1915 only, it has been necessary, in order to obtain figures covering a longer period, to use the run-off of the South Branch of the Nashua River at Clinton. A careful comparison of the rates of run-off of the Nashua with the Millers River during the three years that their records overlapped shows a very close agreement in rates of run-off. The hydrographs attached show the results of operating the reservoirs under the assumptions which in each case are stated on the hydrographs. The time flow curves for the Millers River at Erving and South Royalston show the same results in another way.

TABLE XIV. — *Estimated Annual Power Output from Stored Water in Proposed Millers River Reservoirs.*

No.	NAME OF COMPANY.	Location.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Flow added from Storage in Million Cubic Feet Average, 1907-16.	K. W. H. Output from Stored Water; 20 Per Cent. Waste, Regular Twenty-four-hour Basis.	K. W. H. Output from stored Water; 20 Per Cent. Waste, Regular Hours of Operation.	Annual Value of Power from Storage, at \$0.01 per K. W. H. of Operation.
1	Millers River (Mouth to Windenden). Millers Falls Company, ...	Millers Falls, ...	10	390	14.00	3,100	655,000	273,000	\$2,730
2	Millers Falls Company, ... C. J. Andrews, ...	Millers Falls, ...	10	390	14.00	3,100	655,000	273,000	2,730
3	Millers Falls Company, ...	Millers Falls, ...	-	390	15.00	3,100	704,000	294,000	2,940
4	Millers Falls Paper Company, ...	Millers Falls, ...	24	339	28.00	3,100	1,310,000	1,310,000	13,100
5	Athol Gas and Electric Company, ...	Farley, ...	24	354	16.00	3,100	749,000	749,000	7,490
6	Washburn & Heywood Chair Company, ... W. N. Potter & Son, ...	Erving, ... Erving, ...	10 6	372 372	10.00 8.50	3,100	469,000	195,000	1,950
7	Erving Mills, ...	Erving, ...	24	353	14.50	3,100	679,000	679,000	6,790
8	Athol Gas and Electric Company, ...	Wendell, ...	24	353	21.00	3,100	985,000	985,000	9,850
9	New Home Sewing Machine Company, ... Chase Turbine Manufacturing Company, ...	Orange, ... Orange, ...	10 10	323 323	9.50 10.00	3,100	469,000	195,000	1,950
10	Athol Machine Company, ... N. D. Cass Company, ...	Athol, ... Athol, ...	10 10	206 206	8.50 8.00	1,310	188,000	66,000	660

TABLE XIV. — Estimated Annual Power Output from Stored Water in Proposed Millers River Reservoirs — Concluded.

No.	Name of Company.	Location.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Flow added from Storage in Million Cubic Feet. Average, 1907-16.	K. W. H. Output from Stored Water: 20 Per Cent. Waste, Regular Twenty-four-hour Basis.	K. W. H. Output from Stored Water: 20 Per Cent. Waste, Regular Hours of Operation at \$0.01 per K. W. H.	Annual Value of Power from Storage.
11 {	Wallace Lord, ...	Athol, ...	10	206	9.00	1,310	178,000	74,000	740
12 {	D. E. Adams, ...	Athol, ...	10	206	9.00				
13 {	L. S. Starrett Company, ...	Athol, ...	10	201	18.00	1,310	356,000	182,000	1,320
14 {	Union Twist Drill Company, ...	Athol, ...	10	201	8.00	1,310	188,000	86,000	600
15 {	Athol Manufacturing Company, ...	Athol, ...	10	201	17.75	1,310	351,000	146,000	1,460
16 {	Walker N. Farrar, ...	South Royalston, ...	10	186	10.00	1,310	198,000	82,000	820
17 {	American Woolen Company, ...	South Royalston, ...	10	186	12.50	1,310	247,000	103,000	1,030
18 {	W. M. Whitney, ...	Winchendon, ...	10	55	10.00	95	14,250	6,000	60
19 {	E. Murdock & Co., ...	Winchendon, ...	10	55	13.00	95	18,700	7,800	78
20 {	E. Murdock & Co., ...	Winchendon, ...	10	55	15.00	95	21,500	9,000	90
21 {	Winchendon Electric Light and Power Company, ...	Winchendon, ...	24	55	23.00	95	33,000	33,000	330
22 {	N. E. Lock and Hinge Company, ...	Winchendon, ...	10	55	30.00	95	14,350	6,000	60
23 {	Green & Hickey Leather Company, ...	Winchendon, ...	10	55	10.00	95			
24 {	Mason & Parker, ...	Winchendon, ...	10	54	13.00	95	18,700	7,800	78

23	Baxter D. Whitney & Son,	Winchendon,	24	63	19 00	05	27,370	27,300	278
	<i>Otter River</i>								
26	E. L. Thompson & Co.,	Baldwinville,	70	44	10 00	367	66,200	27,600	276
	Bishop & Dickinson,	Baldwinville,	70	44	12 00				
27	Waite Chair Company,	Baldwinville,	70	44	11 00	367	61,000	25,400	264
	Smith, Day & Co.,	Baldwinville,	70	43	16 00				
28	A. L. Adams Paper Company,	Baldwinville,	74	43	16 00	367	88,500	88,500	885
29	Otter River Board Company,	Otter River,	74	41	15 00	367	88,200	88,200	833
30	Otter River Mills,	Otter River,	10	34	14 00	367	77,400	32,300	323
31	Otter River Yarn Company,	Otter River,	10	33	15 50	367	84,000	35,500	258
	Total, Millers River,	-	-	-	-	37,987	8,931,200	6,082,800	\$60,326
	<i>Connecticut River.</i>								
	Turners Falls Power Company,	Turners Falls,	24	-	55 00	3,100	2,580,000	2,580,000	\$25,800
	Holyoke Water Power Company,	Holyoke,	24	-	53 00	3,100	2,490,000	2,490,000	24,900
	Total, Connecticut River,	-	-	-	-	6,200	5,000,000	5,060,000	\$50,600
	Total, Millers and Connecticut Rivers,	-	-	-	-	46,187	13,991,200	11,092,600	\$110,926

TABLE XIV. (A). — *Water Power on the Millers River in Massachusetts.*

(S. indicates steam; E., electricity.)

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
1	<i>Millers River (Mouth to Windsor).</i> Millers Falls Company.	Millers Falls,	Hardware,	10	390	14.00	202	.410	-	S. and E.	Lower level canal.
2	Millers Falls Company.	Millers Falls,	Hardware,	10	390	14.00	200	.400	10.5	S. and E.	Upper level. Same dam as Millers Falls Company.
3	C. J. Andrews,	Millers Falls,	Grist mill,	-	390	10.00	21	.060	9.6	-	Not in use in 1916.
4	Millers Falls Company.	Millers Falls,	-	-	389	15.00	-	-	-	-	-
5	Millers Falls Paper Company,	Millers Falls,	Paper,	24	389	30.00	595	.850	24.3	S.	-
6	Athol Gas and Electric Company.	Farley,	Electricity,	24	384	16.00	435	.780	14.4	-	-
7	Wachburn & Heywood Chair Company.	Erving,	Furniture,	10	372	10.00	167	.500	14.0	125 S.	8 feet head for 1 wheel, 40 horsepower.
8	W. N. Potter & Son,	Erving,	Grist mill,	6	372	8.50	20	.070	-	-	-
9	Erving Mills,	Erving,	Paper,	24	363	14.50	300	.630	9.5	E.	-
10	Athol Gas and Electric Company.	Wendell,	Electricity,	24	353	21.00	2,200	3.270	25.0	E. and S.	-

9	New Home Sewing Machine Company.	Orange.	10	Sewing machines.	222	9.50	227	1.030	31.4	S.	-
10	Chase Turbine Manufacturing Company.	Orange.	10	Machine shop.	322	10.00	75	.300	}	-	-
11	Athol Machine Company.	Athol.	10	Machine shop.	200	8.50	53	.330	}	S.	-
12	N. D. Case Company.	Athol.	10	Box shop.	200	8.00	40	.270	}	-	-
13	Wallace Lord.	Athol.	10	Grist mill.	200	9.00	40	.240	}	-	-
14	D. E. Adams.	Athol.	10	Silk mill.	200	9.00	30	.180	}	-	-
15	L. S. Starrett Company.	Athol.	10	Tools.	201	18.00	330	1.300	}	S.	250 horsepower on 15-foot head, 120 horsepower on 18-foot head.
16	Union Twist Drill Company.	Athol.	10	Tools.	201	8.00	93	.635	}	S.	-
17	Athol Manufacturing Company.	Athol.	10	-	201	17.75	175	.540	}	-	-
18	Walter N. Farrar.	South Royalston.	-	Wooden measures.	186	10.00	81	.480	}	-	-
19	American Woolen Company.	South Royalston.	10	Woolens.	186	12.50	223	1.125	}	S.	-
20	W. M. Whitney.	Winchendon.	10	-	55	10.00	80 ¹	1.000	}	-	-
21	E. Murdock & Co.	Winchendon.	10	Cooperage.	55	13.00	150	2.310	}	S.	-
22	E. Murdock & Co.	Winchendon.	10	Cooperage.	55	15.00	180	3.400	}	S.	-
23	Winchendon Electric Light and Power Company.	Winchendon.	24	Electricity.	55	23.00	426	3.710	}	-	-
24	Green & Hickey Leather Company.	Winchendon.	10	Toys.	55	10.00	35	.700	}	80 E.	-
25	Mason & Parker.	Winchendon.	10	Leather goods.	55	10.00	35	.700	}	-	-
26	Baxter D. Whitney & Son.	Winchendon.	10	Toys.	54	13.00	98	1.540	}	-	-
27	Nelson D. White & Sons.	Winchendon.	24	Machine shop.	53	19.00	270	3.000	}	E.	-
28	Nelson D. White & Sons.	Winchendon.	10	Cotton goods.	21	21.00	250	6.240	}	S.	Lower privilege.
29	Nelson D. White & Sons.	Winchendon.	10	Cotton goods.	20	21.00	250	6.550	}	S.	Also use Lake Monomonic for storage, 644 acres.

1 Power estimated.

TABLE XIV. (A). — *Water Power on the Millers River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-foot Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
26	<i>Otter River.</i> E. L. Thompson & Co.,	Baldwinville,	Furniture,	10	44	10.00	60	1,500	3.1	8.	-
	Bishop & Dickinson,	Baldwinville,	Furniture,	10	44	12.00	60	1,250			-
27	Waite Chair Company,	Baldwinville,	Furniture,	10	44	11.00	225	5,110	5.3	8.	-
	Smith, Day & Co.,	Baldwinville,	Furniture,	10	43	16.00	124	1,960	92.6	8.	-
28	A. L. Adams Paper Com- pany,	Baldwinville,	Paper,	24	43	16.00	124	1,960			-
29	Otter River Board Company,	Otter River,	Paper,	24	41	15.00	100	1,760	3.9	8.	-
30	Otter River Mills,	Otter River,	Shoddy,	10	34	14.00	195	4,510	2.8	None.	-
31	Otter River Yarn Company,	Otter River,	Yarn,	10	33	15.50	155	3,840	26.0	E.	-
32	Wheeler Manufacturing Com- pany,	East Templeton,	Furniture,	10	3.8	24.00	30	3,620	-	8.	-
33	Bay State Metal Wheel Com- pany.	East Templeton,	Carriages and sleds,	10	3.8	27.00	75	8,050	-	8.	-
34	<i>Eagleville Branch.</i> Rodney Hunt Machine Com- pany.	Eagleville,	Machine shop,	10	16	24.00	135	3,870	216.0	8.	-

	<i>Tully River.</i> F. C. Worrick & Co.,	Tully,	Furniture,	10	16.00	80 ¹	-	-	Tully River partly diverted to West Tully River by canal to Packard Pond.
35	Conrad H. Gale,	Tully,	Boxes,	10	16.00	80	-	-	-
36	<i>Harrisville Branch.</i> Jonas Damon Estate,	Fiskeville, N. H.,	Sawmill,	30	11.00	60	-	-	-
37	Jonas Damon Estate,	Kindge, N. H.,	Furniture,	10	11.00	90	-	-	-
38	<i>Orcutt Brook.</i> G. M. Wheeler & Co.,	Warwick,	Boxes,	10	20.00	50	-	-	-
39	Total,	-	-	-	-	9,340	-	-	-
	Power in New Hamp- shire.	-	-	-	-	150	-	-	-
	Total in Massachusetts,	-	-	-	-	9,190	-	-	-

¹ Power estimated.

TABLE XV. — *Principal Lakes and Ponds on the Millers River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
<i>Tributary below Orange.</i>								
1	Wickett Pond,	Wendell,	-	.60	53	-	-	-
2	Harris Pond,	Warwick,	-	11.50	Small	-	-	Formerly 53 acres. Dam gone.
3	Lake Moore,	Warwick,	-	2.40	31 ¹	-	-	-
4	Hastings Pond,	Warwick,	-	.40	17	-	-	-
5	Pond east of Harris,	Warwick,	G. M. Wheeler & Co.,	10.00	37	4	6.0	Draft estimated.
6	North Pond,	Orange,	Town of Orange,	.70	123 ¹	-	-	Orange water supply. Formerly tributary to Swift River.
<i>Tully River.</i>								
7	Pond northwest of Tullyville,	Warwick,	-	5.00	26	-	-	Earth dam, 150 feet long, 10 to 12 feet high.
8	Pond east of Furnace Village,	Orange,	F. C. Worrick & Co.,	1.00	54	-	-	Part of flow of Tully River diverted through a canal to Packard Pond and thence to pond east of Furnace Village.
9	Packard Pond,	Orange,	F. C. Worrick & Co.,	.30	34	-	-	-
10	Long Pond,	Royalston,	-	20.20	47 ¹	-	-	-
11	Wheeler Pond,	Richmond, N. H.,	-	-	-	-	-	-
12	Meadow Pond,	Fitswilliam, N. H.,	-	11.00	151	-	-	Dam partly gone.
13	South Pond,	Fitswilliam, N. H.,	-	1.20	209	-	-	Numerous summer cottages.



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¹ Area from large scale plan or reliable local sources.

TABLE XV. — *Principal Lakes and Ponds on the Millers River in Massachusetts — Concluded.*

No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
	<i>Otter River — Con.</i>							
36	South Gardner Reservoir (lower).	Gardner.	Bent Brothers.	2.00	98	3	-	Draft estimated.
37	South Gardner Reservoir (upper).	Westminster.	Bent Brothers.	1.00	95	5	-	Draft estimated.
38	Crystal Lake.	Gardner.	City of Gardner.	1.00	153	-	-	Gardner water supply.
39	Pond west of Crystal Lake.	Gardner.	-	6.50	40	-	-	-
40	Lord and Stone Reservoir.	Winchendon.	Lord, Stone & Co.	3.40	116	5	17.0	Earth dam, 200 feet long, 15 feet high.
41	Stoddard Pond.	Winchendon.	-	3.20	27	-	-	-
	<i>Above Winchendon.</i>							
42	Whitney Pond.	Winchendon.	Baxter Whitney & Sons.	55.00	110 ¹	3	15.0	-
43	Lower Naukeag.	Ashburnham.	Baxter Whitney & Sons.	6.70	280 ¹	7	70.0	Low earth dam.
44	Upper Naukeag.	Ashburnham.	Baxter Whitney and town of Ashburnham.	2.00	243	5	50.0	Low earth dam.
45	Lake Monomonaog.	Winchendon Rindge, N. H.	Nelson D. White & Sons.	18.90	644 ¹	13	250.0	Earth dam.
46	Reservoir Pond.	Rindge, N. H.	-	7.30	-	-	-	Formerly 72 acres. Dam gone.
47	Emerson Pond.	Rindge, N. H.	-	.80	96	-	-	-

¹ Area from large scale plan or reliable local sources.

DEERFIELD RIVER.

The Deerfield is the second largest tributary of the Connecticut River in the State of Massachusetts. Its drainage area of 665 square miles is exceeded only by that of the Chicopee River.

The Deerfield River rises in Stratton and Somerset in central Vermont, and flows in a generally southerly direction into Massachusetts to the easterly end of the Hoosac Tunnel, where it makes a sharp turn to the east and flows in a generally easterly direction to the Connecticut River, which it enters just below Greenfield. The total length of the river is about 72 miles, of which 42 miles are in Massachusetts. In Greenfield it is joined by the Green River (with a watershed of 89 square miles) from the north, and at Shelburne Falls by the North River (with a watershed of 92.5 square miles); but with the exception of these two tributaries the watershed is long and narrow, and somewhat fan-shaped at the upper end. It also has a very steep slope, and as a result of the considerable fall and the large drainage area at the upper end of the river it is an exceedingly important water-power stream, comparing with the Westfield in its rapid rise and fall. The basin is steep and rocky with but few lakes and a small amount of storage. Much of it is wooded and but little land is under cultivation.

According to the map showing the rainfall of New England¹ the mean annual precipitation varies from about 46 inches in the southern part to about 40 inches at the headwaters, with an average of about 43 inches, but the mean run-off is so high (estimated at 2.35 second-feet per square mile) that it would seem that the precipitation in the upper part of the basin must be considerably above 40 inches.

The main valley is steep and narrow, being almost entirely without open meadows except near the mouth. On this account, and also because of the great unsteadiness in the flow, the water power of the Deerfield River was but little developed until the recent stage of hydro-electric development was reached.

The principal cities and towns on the basin are shown in the following table: —

¹ Journal of New England Water Works Association, Vol. XXIX., No. 3.

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Buckland, ...	1,569	Greenfield, ...	12,618
Charlemont, ...	977	Hawley, ...	427
Colrain, ...	1,839	Heath, ...	383
Conway, ...	1,230	Monroe, ...	296
Deerfield, ...	2,739	Rowe, ...	424
Florida, ...	427	Shelburne, ...	1,484

Greenfield, noted for its tap and die works and machine shop products, is located at the mouth of the river. Its growth has been entirely independent of water power, only a very small amount having been developed from the Green River. There is a certain amount of manufacturing in Shelburne Falls, which was originally attracted by the water power developed there at an early date, and there are also a few small mills on the North Branch in Colrain, and on the South Branch in Conway; but outside of these places the basin in Massachusetts is entirely without manufacturing industries, and further north in Vermont the industries are limited to lumbering and lumber products.

Greenfield, Shelburne Falls and Colrain have small surface water supplies which are relatively unimportant as compared with the basin as a whole.

Developed Water Power.

The Deerfield River contains a number of large and important hydro-electric developments, with a total installed capacity of water wheels of 56,912 horsepower, as shown by Table No. XVI. on pages 104 and 105. The first hydro-electric plant was built in 1905 by the Greenfield Electric Light and Power Company at Gardner Falls, a short distance below Shelburne Falls. This was followed in 1912 by four developments in Massachusetts and one in Vermont by the New England Power Company, which sells power to and is essentially a part of the Connecticut River Transmission Company. The methods of development in these hydro-electric plants vary. At Station No. 2, below Shelburne Falls, a concrete dam 90 feet high in maximum sec-

tion adjoins the power station, and creates the entire head of 63 feet. At Station No. 3, in the village of Shelburne Falls, the head is developed by means of a concrete dam on ledge, with a canal, and a reinforced concrete conduit that passes underneath the buildings of the Samson & Goodnow Manufacturing Company who formerly utilized this privilege. At Station No. 4, just above Shelburne Falls, a concrete dam of 44 feet maximum height diverts the water through a horseshoe-shaped tunnel 1,600 feet long, which was driven across a bend in the river, and ends at a forebay from which steel penstocks carry the water to the power station under a maximum gross head of 70 feet.

The largest power development is that at Station No. 5, above the Hoosac Tunnel. The dam which is located at Monroe Bridge diverts the water through a tunnel 1,100 feet long, and from thence it is carried in a concrete conduit and open canal a total distance of 3 miles down the river to a reinforced concrete surge tank from which three steel pipes 550 feet long extend to the power station. A normal head of 233 feet is developed and three water-wheel units are installed with a total of 22,500 horsepower, which is nearly as large as the aggregate of all the water wheels installed on the Merrimack River at Lawrence.

Undeveloped Water Power.

Ascending the river from the mouth, at which point it is at an elevation of about 105 feet above mean sea level during normal stages of the Connecticut River, there is a total rise of 124 feet in a distance of 13 miles, now unused, before the tail-water of Station No. 2 is reached. The greater part of this fall occurs in the first 7 miles below Station No. 2, and a considerable part of this could undoubtedly be developed. From the tail-water of Station No. 2 to the top of the flashboards at Station No. 4 there is a total rise of 243 feet. This is all taken up by the three power stations of the New England Power Company and that of the Greenfield Electric Light and Power Company, which follow each other in succession with little or no undeveloped fall in between. Of this total of 243 feet gross head an average net working head of about 223 feet is obtained. The pond above Station No. 4 extends up-stream about a mile, or

nearly to East Charlemont, and from this point to the tail-race of Power Station No. 5 there are no developments. The total distance along the river between these two points is about 1.5 miles, and the rise amounts to 314 feet. Just how much of this could be economically developed has not yet been determined, but it is doubtless all owned by the New England Power Company. It would appear that the undeveloped stretch between Power Station No. 5 and the Hoosac Tunnel could easily be developed, and also that between Hoosac Tunnel and the mouth of Cold River, about a mile below Zoar, although the Fitchburg Division of the Boston & Maine Railroad parallels the stream in this latter stretch and might be affected in places. From Cold River down to the pond of Station No. 4 the opportunities for development appear less favorable, although a part of this fall might be developed in the vicinity of Charlemont. The total of these two undeveloped stretches in Massachusetts amounts to 438 feet. On the assumed basis of installing and developing the mean flow of the river, which is estimated at 2.35 second-feet per square mile for the Deerfield River, the undeveloped power on this stream amounts to 30,400 horsepower.

The pond above Power Station No. 5 extends nearly to the New Hampshire-Vermont line. Two and a half miles above the State line is the New England Power Company's Station No. 7 at Readsboro, Vt., where a head of 76 feet is obtained. Between the tail-race of No. 7 and the pond of No. 5 there is an undeveloped fall of 70 feet, the greater part of which is in the State of Vermont. Again, between Readsboro and Wilmington there is a long undeveloped stretch of the river. At Wilmington the Mountain Mills Lumber Corporation have developed a head of 26 feet, which is the only power development of size on the Deerfield River in Vermont, excepting that at Readsboro previously mentioned.

In 1913 Mr. E. H. Harriman, president of the New England Power Company, stated before the Water Conservation Commission that the Deerfield River had a total fall of from 1,300 to 1,400 feet, of which the New England Power Company owned a total of about 1,100 feet. Nearly one-half of this is now present in use.

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Storage.

The natural storage on the Deerfield River is exceedingly small, as there are but two or three small and unimportant ponds in Massachusetts and but few ponds in Vermont. In 1912 the New England Power Company created a large reservoir at Somerset, Vt., with a storage of 2,675,000,000 cubic feet, by the construction of an earth dam 2,100 feet long and of 110 feet maximum height. This reservoir cost about \$800,000 and completely controls the run-off of the 30.2 square miles above. The company states that during low water this storage will maintain the flow of the Deerfield River at Station No. 5 at 400 second-feet in an average year.

If additional storage is required it must also be obtained in Vermont, and it is understood that the New England Power Company has made plans and surveys for another large reservoir.

TABLE XVI. — *Water Power on the Deerfield River in Massachusetts.*

(S. indicates steam; G., gas.)

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-foot per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
<i>Deerfield River.</i>											
1	New England Power Company, Station No. 2.	Shelburne and Con-	Electricity,	24	507	53	9,600	3.60	43 ¹	-	-
2	Greenfield Electric Light and Power Company.	Shelburne and Buck-	Electricity,	24	502	37	4,100	2.43	35	-	-
3	New England Power Company, Station No. 3.	Shelburne Falls,	Electricity,	24	499	64	9,600	3.31	25 ¹	-	-
4	New England Power Company, Station No. 4.	Shelburne Falls,	Electricity,	24	404	64	9,600	4.09	39 ¹	-	-
5	New England Power Company, Station No. 5.	Monroe and Florida,	Electricity,	24	246	233	22,500	4.32	10.5 ¹	-	-
<i>Deerfield River in Vermont.</i>											
6	New England Power Company, Station No. 1.	Readsboro, Vt.,	Electricity,	24	190	72	3,800	3.06	25 ¹	-	-
7	Deerfield Lumber Corporation,	Mountain Mills, Vt.,	Lumber,	-	155	26	-	-	-	-	-
<i>Green River.</i>											
8	Wiley & Russell Manufacturing Com-	Greenfield,	Tools,	-	88	-	-	-	-	-	-
9	Greenfield Electric Light and Power Company.	Greenfield,	Electricity,	24	88	10	100	1.25	-	-	-

<i>North River.</i>											
10	Shelburne Falls & Colrain Street Railway Company.	Colrain.	Electricity.	15	92	21	250	1.42	-	5.	-
11	Massacot Yarn Mills.	Shattuckville.	Cotton goods.	9	88	28	312	1.40	-	100 S.	-
12	Griswoldville Manufacturing Company.	Griswoldville.	Cotton goods.	9	85	22	190	1.12	-	350 S.	-
13	Griswoldville Manufacturing Company.	Colrain.	Cotton goods.	9	51	32	185	1.25	-	175 S.	-
14	W. W. Cary & Son.	Colrain.	Cider mill.	-	30	-	-	-	-	-	-
15	Purinton & Gildchrist.	Colrain.	Sawmill.	-	-	11	53	-	-	-	-
<i>South River.</i>											
16	Conway Electric Street Railway Company.	Conway.	Electricity.	16	25	95	150	.70	-	None	-
17	H. G. Reed.	Conway.	Tool handles.	9	24	40	74	.85	-	None	-
18	DeWolfe Shoe Company.	Conway.	Shoes.	9	20	25	50	1.10	-	-	-
19	DeWolfe Shoe Company.	Conway.	Shoes.	9	20	37	100	1.49	-	30 G.	-
20	Conant & Donelson Company.	Conway.	Tools.	9	20	23	45	1.15	-	35 G.	Reservoir above.
Total in Massachusetts.		-	-	-	-	-	55,912	-	-	-	-

¹ Area of pond at crest of dam.

At New England Power Company Station No. 2, area of pond is 51 acres at an elevation 4 feet above crest.
 At New England Power Company Station No. 3, area of pond is 33 acres at an elevation 2 feet above crest.
 At New England Power Company Station No. 4, area of pond is 55 acres at an elevation 4 feet above crest.
 At New England Power Company Station No. 5, area of pond is 13.5 acres at an elevation 2 feet above crest.
 At New England Power Company Station No. 6, area of pond is 50 acres at an elevation 8 inches above crest.

CHICOPEE RIVER.

The Chicopee River drains a large section in the central part of Massachusetts comprising portions of Worcester, Franklin, Hampshire and Hampden counties. It is the largest tributary of the Connecticut River, and is also the largest river entirely within the State of Massachusetts. The main stream is formed at Three Rivers by the union near that point of the Quaboag, Ware and Swift rivers, and from thence runs westerly a distance of about 15 miles to the Connecticut River, which it enters midway between Springfield and Holyoke. The total drainage area is 721 square miles, of which 210 square miles are contributed by the Quaboag, 221 by the Ware and 216 by the Swift.

The country drained is hilly, but a large proportion of the land has been favorably situated for agricultural purposes, and the valleys are sufficiently open to accommodate the large villages and important towns that now occupy them.

The watershed of the Chicopee River has a mean annual rainfall of about 44 inches. The flow is well sustained, as the basin contains many lakes and ponds, together with flat and swampy regions which help to maintain the dry season flows. The amount of artificial storage at present under control is not large, but is sufficient, together with the natural storage, to prevent disastrous floods which are entirely unknown on this watershed.

The following table shows the principal cities and towns in the watershed, with the population in 1915:—

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Barre, ...	3,476	North Brookfield, ...	2,947
Belchertown, ...	2,062	Oakham, ...	527
Brimfield, ...	824	Palmer, ...	9,468
Brookfield, ...	2,059	Pelham, ...	498
Chicopee, ...	30,138	Petersham, ...	727
Dana, ...	712	Phillipston, ...	800
Enfield, ...	806	Prescott, ...	299
Greenwich, ...	426	Rutland, ...	1,896
Hardwick, ...	3,596	Shutesbury, ...	292
Hubbardston, ...	1,084	Spencer, ...	5,694
Ludlow, ...	6,251	Ware, ...	9,246
Monson, ...	5,004	Warren, ...	4,368
New Braintree, ...	453	West Brookfield, ...	1,288
New Salem, ...	626	Wilbraham, ...	2,521

Water Power.

The water power on the river was largely developed at an early date, and as a result by far the greater part of it is used directly in manufacturing industries. The details are shown in Table No. XVII., on pages 115 to 119. The textile mills form the most important industry on the river, and use about 18,700 horsepower of the total installed wheel capacity of about 36,500 horsepower. The Ludlow Manufacturing Company has the largest installation amounting to 9,075 horsepower, which is used for manufacturing hemp and jute. The greater part of this power is developed at their hydro-electric station at Red Bridge, from which the energy is transmitted electrically to Ludlow. The only commercial hydro-electric developments are those of the United Electric Company of Springfield and the Central Massachusetts Power Company at Palmer. The United Electric Company has two plants on the Chicopee River, one at Bircham Bend and the other at Indian Orchard, where a part of the power is used directly in the cotton mills controlled by the United Electric Company. These three hydro-electric plants have a total of 5,700 horsepower. In addition to these industries there are two paper mills, one wire mill and several small mills manufacturing miscellaneous products which make use of the water power of the Chicopee River and its tributaries.

The watershed is well supplied with electric transmission lines, including those of the Connecticut River Transmission Company, extending from near Greenfield in nearly a straight line to Ware, at which point they are connected with the lines of the Central Massachusetts Electric Company, with which it is affiliated. From Ware the lines of the Connecticut River Transmission Company also run to Millbury south of Worcester, where they connect with their line that comes from Vernon through Gardner, Clinton and Worcester. The lines of the Central Massachusetts Electric Company extend to Warren, Brookfield, Spencer, Palmer, Wilbraham and East Longmeadow. The transmission lines of the Turners Falls Power and Electric Company supply power to the lower part of the watershed at Ludlow, Chicopee, Chicopee Falls and Spring-

field, and are connected physically at the latter place with the power station of the United Electric Company.

The greater part of the water power on the watershed is on the 15 miles of main river between Chicopee and Three Rivers, where the drainage area varies from 647 square miles to 721 square miles, with a total fall of 258 feet, which has been so completely developed that the mill ponds succeed one another with but little unutilized fall between them. Two-thirds of the installed water-wheel capacity on the Chicopee watershed is located on this part of the river.

The Quaboag, the southernmost of the three branches which unite at Three Rivers, is closely followed by the main line of the Boston & Albany Railroad. From Three Rivers to Palmer there is only a little more fall in the river than is required to take care of the flood flow. In Palmer there is a low head privilege, formerly occupied by the Quaboag Leather Company, which is not now in use, and just above is the hydro-electric development of the Central Massachusetts Power Company previously referred to. Above this occurs the only stretch of undeveloped power on the Quaboag River, which extends from the Central Massachusetts Power Company's pond, a distance of $6\frac{1}{2}$ miles, to the lowest of the Thorndike Company's privileges in West Warren, which includes an unutilized privilege of 12 feet just below the Thorndike Company's lowest dam. The total undeveloped head amounts to about 161 feet, warranting an installation of 2,960 horsepower on the basis of 1.55 second-feet per square mile of mean flow.

Between West Warren and Warren there are six privileges developing a total head of 76 feet out of a difference in elevation between these two points of 91 feet. The undeveloped fall between these points is distributed between the various privileges, the greatest being between the uppermost privilege of the Thorndike Company and that of Sayles & Jencks in Warren, where there is an unutilized fall of about 10 or 11 feet.

The last dam on the Quaboag River at Warren is a short timber dam 6 or 7 feet high that is controlled by the Sayles & Jencks Manufacturing Company. Above this dam the pond apparently sets back a distance of about 10 miles, through the Brookfield Meadows, to East Brookfield. It is possible to

travel in a boat without meeting any rapids from Warren to East Brookfield through Quaboag or Podunk Pond, and also up to South Pond. This stretch of river constitutes a most important pondage on the Quaboag River, although a line of levels showed that it is only partly controlled by the dam at Warren, as there is a rise of from 5 to 10 feet in the water surface which occurs in the 3 miles or so between the dam at Warren and West Brookfield. Apparently this slope is required to carry the water from the Brookfield Meadows down to Warren, and the pond proper might be said to begin at the railroad bridge in West Brookfield. From this point to East Brookfield, a distance of over 7 miles, there is no rise in the water level.

The extensive meadows bordering the river channel are flowed during periods of high water, and the pondage resulting must be large, although it is impossible to estimate its amount, as the ground-water storage in the meadows constitutes a considerable part of it. Above the Brookfield meadows there are small power developments at East Brookfield and on the Turkey Hill branch of the Seven Mile River above Spencer.

The Ware River is an important water-power stream for its size, and is largely in use from its junction with the Swift River as far as Coldbrook. It is closely followed along the greater part of the distance between these two points by the Central Massachusetts Railroad and the Ware River Branch of the Boston & Albany Railroad. The total fall between Coldbrook and Three Rivers amounts to 350 feet, with a total developed head of 226 feet, on which wheels of a combined capacity of 5,940 horsepower are installed. The undeveloped head in this part of the Ware River is so distributed that it does not afford any single important privilege. There is an undeveloped head of about 36 feet between the upper privilege of the Thorndike Company at Thorndike and the lowest privilege at Ware, and of about 27 feet additional between Ware and Gilbertsville, the greater part of which is located directly below Gilbertsville and could doubtless be developed by means of a canal. At Coldbrook there is a flat stretch of the river, and directly above this, at Barre Falls, is the only important undeveloped water-power privilege on the Ware River. At this point the river has a drainage area of 57 square miles. The river plunges down over

a granite ledge, and by building a dam 30 or 40 feet in height above the falls a storage reservoir of considerable value can be created, which will be discussed later, and a head of about 125 feet could be obtained, according to the topographical map, thus making possible the development of about 903 horsepower on the basis of the mean flow of the river. The proposed reservoir of the metropolitan water supply system at Coldbrook is located below Barre Falls, and will be described later.

The Otis Company's pond at Three Rivers extends some distance up the Swift River, and above it there are two abandoned privileges, formerly in use at West Ware and Barrett Junction, on each of which from 8 to 10 feet of head was obtained.

The most important developments on the Swift River are those of the Boston Duck Company at Bondsville, between the two abandoned privileges just referred to. The flow of the river is fairly well used at Enfield and above, although the fall is so small that the power developments are unimportant, and no new privilege could be created.

Storage.

As previously stated, the natural storage facilities on the Chicopee watershed are excellent, and a considerable number of the ponds are regulated. The principal lakes and ponds and the extent of their use for storage are shown by Table No. XVIII., on pages 120 to 122.

Any plan for increasing storage on the Chicopee River must take into consideration the probable extension of the metropolitan water system. In 1895 an extensive investigation was made by Mr. Frederic P. Stearns, at that time chief engineer of the State Board of Health, for the purpose of determining a comprehensive policy for the expansion and enlargement of the water supply for Boston and the remainder of the metropolitan district. The use of Lake Winnepesaukee, of filtered Merrimack River water, and other sources were considered, but the plan finally adopted was the construction of the Wachusett Reservoir on the South Branch of the Nashua River at Clinton, which was built at a cost of about \$11,000,000. At the time the investigation was made it was estimated that the demand for water by the metropolitan district would have so increased by 1915 that the entire flow from the South Branch of the

Nashua and the rest of the system would be required and an additional new supply needed. It was proposed to first add a part of the Assabet River, which is a tributary of the Concord. This would add the run-off from 34.4 square miles, and when a still further supply was required the plan was to take the Ware River. It was proposed to construct a dam about 70 feet high and 785 feet long just below Coldbrook, flooding an area of 1,035 acres and providing storage for 11,190,000,000 gallons, or 1,500,000,000 cubic feet. The water was to be conducted from this watershed into the Nashua River through a tunnel 8.72 miles long. This use of the Ware River would practically destroy its usefulness as a source of water power, and would prevent the use of the river above for storage for the benefit of the various mills below.

Due to the installation of meters and the checking of waste, the demand of the metropolitan district for water has been kept down to about 102,000,000 gallons per day in 1915, instead of rising to 173,000,000 gallons, which is the capacity of the present system, as was anticipated in 1895. It is impossible to say when it will be necessary to increase the supply, but after that created on the upper Ware at Coldbrook has been exhausted it is proposed to tap the river again above Gilbertsville, adding an additional drainage area of 56 square miles. After this it is proposed to utilize the Swift River by the construction of a dam below Enfield which will flood an area of 36.9 square miles, creating the largest body of water within this State, completely controlling the flow of the Swift River and wiping out several villages. The date at which the Swift River will be required is so remote that it need hardly be considered in connection with the present investigation, but the necessity of adding the upper Ware to the metropolitan system appears so certain in the not far distant future that it would hardly seem worth while to make any plans for using the river above the point of diversion at Coldbrook.

At different times in the past various owners of the water-power rights on the Chicopee River and its tributaries have co-operated in having surveys made to determine the possibility of creating storage reservoirs. It would seem that as practically all the manufacturing establishments on the river are equipped with auxiliary steam plants, such water as might be stored dur-

ing the winter months and released during the dry season in the summer would replace a sufficient amount of coal to justify the construction of additional storage reservoirs.

The general storage situation on the three branches of the Chicopee River is as follows:—

It would be possible to create a large storage reservoir on the Quaboag River by the construction of a dam from 600 to 800 feet long a short distance below the West Brookfield station flooding the Brookfield meadows. This dam would not have to be over 15 to 18 feet high in order to give a large amount of storage, but the flowage damage would be very great, and may outweigh any benefits resulting from the control of this 105 square miles of drainage area. The main line of the Boston & Albany Railroad between West Brookfield and East Brookfield, a distance of over 6 miles, would have to be relocated, and a large part of the town of Brookfield would be flooded as well as the location of numerous summer cottages that have been built around Podunk Pond and South Pond, and a considerable amount of good farming land.

There are no other possibilities on the Quaboag River for a large amount of storage, but there are four sites for reservoirs of moderate size.

The most promising of these is on Blodgett's Mill Brook in the town of Brimfield, where a dam 300 to 400 feet in length and 25 to 30 feet high would flood a flat swampy meadow which, from the Geological Survey map, would appear to have an area of about 240 acres. An inspection of the ground indicates conditions similar to those shown on the map, and a storage of about 200,000,000 cubic feet would thus be afforded with a drainage area of 6 square miles. Only a small proportion of the land to be flowed is of much value for farming purposes and no houses would be affected, but it would involve raising a short stretch of road.

The second site referred to above is Wickaboag Pond, which is already used for storage to a depth of 6 feet, although there are from a dozen to twenty summer camps surrounding the pond, but most of these are well above the water level. A dam of moderate length could be built which would raise the water level 15 feet, the greatest damage being to a highway which

passes the upper end of the pond. This road would have to be raised or relocated for a distance of nearly three-quarters of a mile, and as there is already about 56,000,000 cubic feet of storage available in this pond it is possible that the additional storage would not be worth the cost. Driven wells and a pumping station for the water supply of West Brookfield are located near the lower end of the lake, and would be affected by the proposed change.

The third site is on Five Mile River a short distance above Lake Lashaway. The stream has but little fall between Lake Lashaway and Brooks Pond, and although a long dam would be required its height would not have to be over 20 to 30 feet to flood back to the level of Brooks Pond, and a higher dam would give an additional draft on Brooks Pond, but this is an artificial reservoir formed by a dam 250 feet long and of 15 feet maximum height. The water rights to it would have to be acquired, but only poor timber land would be flowed, although there are at the present time eight summer camps on the shores of the pond.

The last site on the Quaboag watershed is on the Turkey Hill branch of the Seven Mile River in Spencer, at the Thompson Reservoir of the Spencer Wire Company, who have a dam about 300 feet long and 26 feet high, with about 57,000,000 cubic feet of storage. From 200 to 400 feet below this site a dam 600 to 700 feet long and 50 feet high could be built, raising the present reservoir about 20 feet and adding approximately 200,000,000 cubic feet of storage, as nearly as can be determined from the information available. The land flowed is not very valuable, although the road crossing the center of the present reservoir would have to be relocated.

On the Ware River there are several storage possibilities, but they are all located above the proposed reservoir of the metropolitan water system at Coldbrook. There is one excellent storage site above Barre Falls which has been previously described and is referred to in the 1880 water-power census as follows: —

The reservoir capacity of the stream can be largely increased, and a plan looking to that end has already been developed. At Barre Falls, by a dam 25 feet high and from 300 to 400 feet long, a flowage of 1,170 acres

could be obtained with a storage of about 490,000,000 cubic feet, and it is estimated that the reservoir could be filled three times in each year. Some \$12,000 has already been expended in buying land and engineering and other work. It is estimated that as much as \$70,000 would be required to complete the enterprise. Toward the actual construction of the reservoir no work has yet been done on account of a disagreement among the mill owners as to bearing the expense. Nearly all the mill owners along the river are interested in the project, which is still under consideration.

This project has been under consideration several times since the date of the above report, but nothing has ever come of it. A part of the farm connected with the State prison in Hubbardston would be flowed by this reservoir.

There are four other places on the upper part of the Ware River where small amounts of storage can be obtained, but all of them would be subject to the needs of the metropolitan water district in the same way as the Barre Falls project.

The most promising site of the four referred to is on Natty Pond Brook; the other three are on the Burnshirt River, — the lowest at Williamsville, the second the Sawyer Reservoir, and the third the flat and swampy region a short distance east of Phillipston.

The best opportunity for adding to the storage on the Swift River is on the West Branch, a mile or so above its junction with the East and Middle branches, which has been investigated by private interests, and it was found that a 60- to 70-foot dam would flood back 4 or 5 miles, including a region that is largely poor timber land and of small value. There is no ledge appearing at the surface near the dam site, the surface soil of the valley being sandy, which is true of the greater part of the Chicopee watershed. A reservoir here would also be entirely independent of the proposed expansion of the metropolitan water system.

The difficulty with the use of the East and Middle branches of the Swift River is that they are included by the dam proposed below Enfield for creating a reservoir for the metropolitan district, and this entire region is so very flat that the necessary dams would be long and expensive, and if built of any height they would flood one or more villages and require the moving of railroads.

TABLE XVII. — *Water Power on the Chicopee River in Massachusetts.*
[S. indicates steam; E., electricity; G., gas.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
<i>Chicopee River.</i>											
1	Dwight Manufacturing Company.	Chicopee.	Cotton goods.	9	718	28.0	2,000	1.10	33.0	4,700 S. S. and E. 50 S.	Take water from upper canal.
	A. G. Spaulding Brothers Manufacturing Company.	Chicopee.	Sporting goods.	9		15.0	300	.31			Take water from middle dam.
	Ames Sword Company.	Chicopee.	Cutlery.	9		14.0	46	.05			Privilege includes both dams.
2	Johnson and Johnson.	Chicopee Falls.	Cotton goods.	9	714	26.0	2,200	1.90	82.0	2,200 S. 500 E. S. and E.	Upper dam.
	Lamb Knitting and Manufacturing Company.	Chicopee Falls.	Machine shop.	9		14.4	41	.04			Lower dam.
	National Scale Company.	Chicopee Falls.	Machine shop.	9		9.0	250	.43			
3	United Electric Company.	Bircham Bend.	Electricity.	24	704	12.0	900	1.17	91.0	-	-
4	United Electric Company.	Bircham Bend.	Electricity.	24	687	23.0	2,600	1.60	85.0	-	-
5	Ludlow Manufacturing Company.	Ludlow.	Jute goods.	-	686	28.0	1,700	.97	4.0	-	-
6	Ludlow Manufacturing Company.	Ludlow.	Jute goods.	-	686	12.0	750	1.00	93.0	-	-
7	Collins Manufacturing Company.	Collins Station.	Paper.	24	681	11.0	1,200	1.76	79.0	S.	-
8	Ludlow Manufacturing Company.	Red Bridge.	Jute goods.	-	664	50.0	7,300	2.42	185.0	-	Electric plant only at Red Bridge.
9	Otis Company.	Three Rivers.	Cotton goods.	9	647	22.0	3,375	2.61	60.0	-	Head estimated.

TABLE XVII. — *Water Power on the Chicopee River in Massachusetts* — Continued.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-foot per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
10	<i>Swift River.</i> Boston Duck Company,	Bondville,	Cotton goods,	9	195	22.0	550	1.41	6.0	8.	-
11	Boston Duck Company,	Bondville,	Cotton goods,	9	195	22.0	550	1.41	57.0	8.	-
12	Quabbin Manufacturing Company.	Enfield,	Woolen goods,	9	135	11.0 13.0 17.0	200	1.25	-	-	-
13	Grant S. Kelley Woolen Mills.	Esfield, Smiths Village.	Woolen goods,	9	133	11.0	201	1.51	-	-	Davis Pond for pondage.
14	A. W. Mason,	Prescott, Soapstone Village.	Electricity and boxes.	9	49	6.5	40	1.33	-	-	Electric light plant and North Dana Box Company.
15	Crawford & Tyler,	North Dana,	Woolen goods,	9	29	8.5	33	1.70	-	-	Neesponset Pond for pondage.
16	W. A. Moore,	Millington,	Grist mill,	9	13	10.0	100	8.43	-	-	-
17	<i>East Branch, Swift River.</i> Walker,	Greenwich Village,	Grist mill and saw-mill.	-	50	10.0	100	2.20	-	-	-

TABLE XVII. — *Water Power on the Chicopee River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
38	<i>Prince River.</i> Charles G. Allen Company,	Barre, . . .	Agricultural imple- ments.	9	5	14.0	30	4.71	-	-	-
39	<i>Quebec River.</i> Central Massachusetts Power Company.	Palmer, . . .	Electricity, . . .	24	177	16.0	1,300	4.65	40.0	8.	-
40	Thorndike Company, . . .	West Warren, . . .	Cotton goods, . . .	9	145	16.0	1,600	2.53	3.5	1,775 S.	-
41	Thorndike Company, . . .	West Warren, . . .	Cotton goods, . . .	9	142	16.0			2.5		-
42	Thorndike Company, . . .	West Warren, . . .	Cotton goods, . . .	9	141	15.0			5.0		-
43	Thorndike Company, . . .	West Warren, . . .	Cotton goods, . . .	9	141	12.0			2.7		-
44	Sayles-Jenks Manufacturing Company.	Warren, . . .	Woolens, . . .	9	133	10.0	220	1.75	9.5	-	-
45	Sayles-Jenks Manufacturing Company.	Warren, . . .	Woolens, . . .	9	137	7.0	100	-	-1	-	-
46	Mann & Steven Woolen Com- pany.	East Brookfield, . . .	Woolen goods, . . .	9	33	14.0	60	1.24	-	-	-

Power estimated. Used pri-
marily for pondage.
Pondage to equalize low flow.

47	Spencer Wire Company,	Wire Village,	Wire,	9	16	30.0				
48	Spencer Wire Company,	Wire Village,	Wire,	9	-	15.0				
						11.0				
49	Spencer Wire Company,	Wire Village,	Wire,	9	-	26.0	275	-	E.	-
50	Spencer Wire Company,	Wire Village,	Wire,	9	-	15.0				
51	Spencer Wire Company,	Wire Village,	Wire,	9	-	20.6				
52	Spencer Wire Company,	Wire Village,	Wire,	9	-	25.0				
	Total,	-	-	-	-	-	35,396	-	-	-

! Pondage large, extending up into Brookfield meadows.

Summary.		Horsepower.
Chicopee River,	.	24,662
Swift River,	.	1,779
Ware and Primes rivers,	.	6,470
Quabong River,	.	3,455
Total,	.	36,366

TABLE XVIII. — *Principal Lakes and Ponds on the Chicopee River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

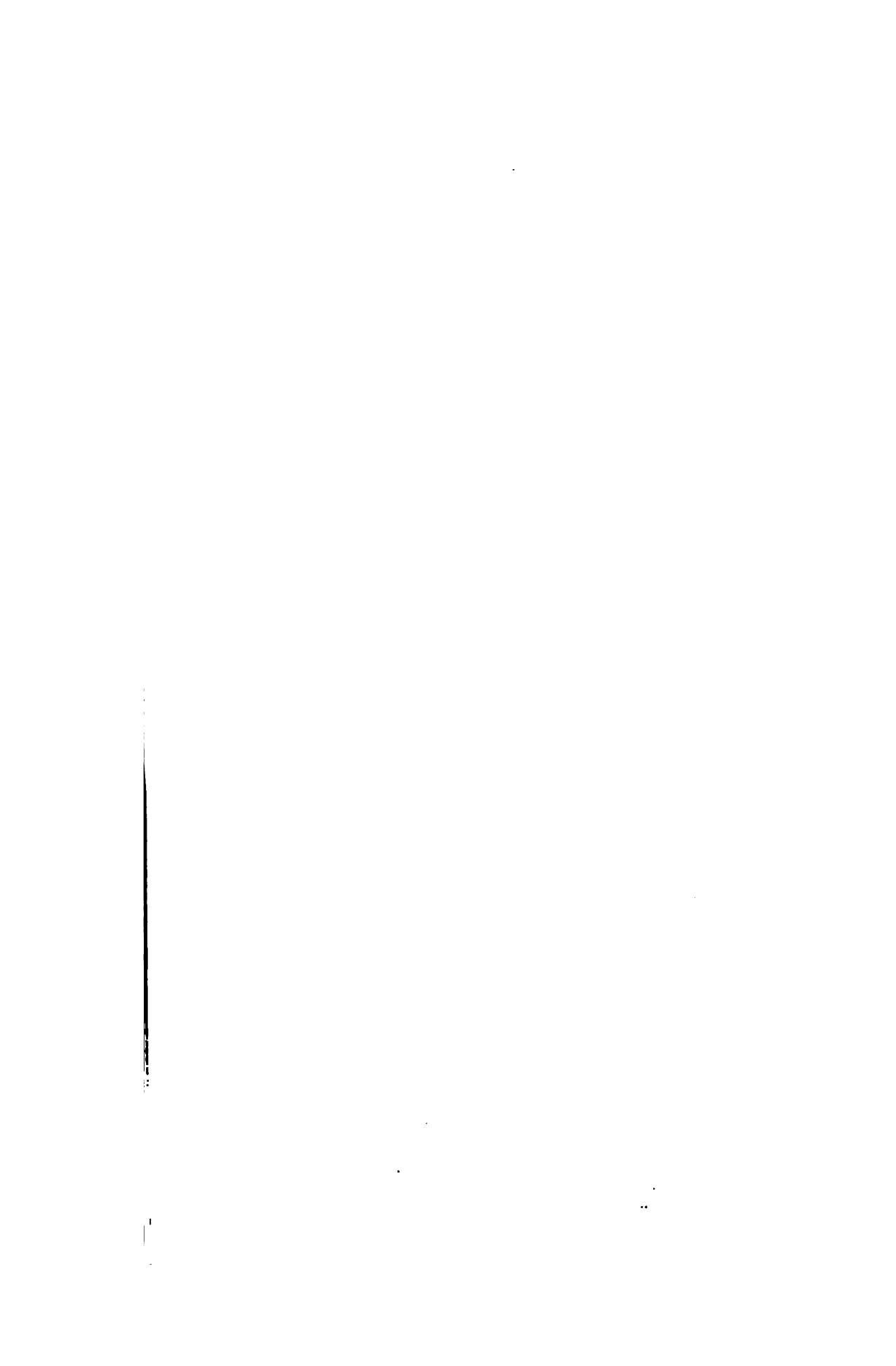
No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
	<i>Quabog River.</i>							
1	Turkey Hill Pond, . . .	Paxton and Rutland, .	Eames, . . .	1.10	65	3.0	8.0	Natural pond raised 3 feet by small earth and stone dam.
2	Eames Pond, . . .	Paxton, . . .	Eames, . . .	2.40	98	8.0	-	Earth dam, 12 feet high, 250 feet long.
3	Thompson Reservoir, . . .	Spencer, . . .	Spencer Wire Company, .	11.60	122 ¹	20.0	58.0	Earth dam, 300 feet long, 30 feet maximum height.
4	Sugden Reservoir east of Wire Village, . . .	Spencer, . . .	Spencer Wire Company, .	5.80	90 ¹	15.0	30.0	Earth dam, 400 feet long, 25 feet maximum height.
5	Moose Pond, . . .	Spencer, . . .	- . . .	.80	54	-	-	Earth dam, 300 feet long, 13 feet maximum height.
6	Shaw Pond, . . .	Leicester, . . .	Town of Spencer, . . .	.50	80	-	-	Spencer water supply.
7	Browning Pond, . . .	Oakham and Spencer, .	- . . .	3.40	89	-	-	Formerly used for storage. Draft about 3 feet.
8	Brooks Pond, . . .	North Brookfield and Spencer, .	- . . .	14.20	200	7.0	-	Earth dam, 250 feet long, 15 feet maximum height. Eleven summer camps.
9	Horse Pond, . . .	North Brookfield, . . .	North Brookfield, . . .	.24	32	-	-	North Brookfield water supply.
10	Furnace or Lake Lashaway, .	North Brookfield and Brookfield, .	- . . .	24.90	203 ¹	4.0	43.0	Earth and stone dam.
11	Cranberry Meadow Pond, . .	Spencer and Charlton, .	- . . .	.90	63	-	-	- . . .
12	South Pond, . . .	Brookfield and Sturbridge, . . .	- . . .	.80	285	-	-	Natural pond. Numerous summer camps.
13	Quabog or Podunk Pond, . .	Brookfield, . . .	- . . .	77.00	512	-	-	Natural pond. Water level partly controlled by dam at Warren.
14	Pond west of Quabog, north, .	Brookfield, . . .	Rice, . . .	3.20	22	-	-	Earth dam about 200 feet long.
15	Pond west of Quabog, south, .	Brookfield, . . .	Rice, . . .	2.80	40	6.0	6.5	Earth dam, 300 feet long, 10 feet maximum height.
16	Wickabog Pond, . . .	West Brookfield, . . .	Thorndike Company, . .	17.90	321	4.0	56.0	Low earth dam. Summer camps.

17	<i>Swift River.</i> Pottapaug Pond,	Dana,	-	-	43.50	254	-	-	Natural pond.
18	East Pond,	Greenwich,	-	-	53.00	100	-	-	Natural pond. Several summer camps.
19	Davis Pond,	Greenwich,	-	Grant S. Kelly Company.	71.00	41	1.5	2.7	Controlled by flashboards.
20	Curtis Pond,	Greenwich,	-	-	3.20	20	-	-	Natural pond.
21	Warners Pond,	Greenwich,	-	-	1.10	28	-	-	Natural pond.
22	Sunk Pond,	Dana,	-	-	.80	19	-	-	-
23	Neeseponset Pond,	Dana,	-	Crawford & Tyler Woolen Company.	28.40	100	2.0	8.5	Used for pondage. Timber dam.
24	Thompson Pond,	New Salem,	-	W. A. Moore,	8.80	128	10.0	32.0	Wooden dam, 13 feet high.
25	Hop Brook Pond,	New Salem,	-	-	12.40	36	-	-	Natural pond.
26	Pond northwest of Petersham,	Petersham,	-	-	3.30	110	-	-	Earth and stone dam, 160 feet long, 8 feet maximum height.
27	Pond west of Petersham,	Petersham,	-	-	5.30	35	-	-	Low earth and stone dam.
28	Knight and Gould Reservoir,	Belchertown,	-	City of Springfield,	1.00	36 ¹	-	-	Springfield water supply, Ludlow system.
29	<i>Ware River.</i> Lovtwell Reservoir,	Hubbardston,	-	-	1.70	169	-	-	Earth and stone dam, 200 feet long, 10 feet maximum height.
30	Waite Pond,	Hubbardston,	-	-	1.60	90	-	-	Low earth and stone dam.
31	Moose Horn Pond,	Hubbardston,	-	Hygienic Blanket Company.	.60	106	4.0	15.0	Earth dam, 250 feet long, 6 feet maximum height.
32	Brigham Pond,	Hubbardston,	-	Hygienic Blanket Company.	12.70	50	4.0	8.0	Earth dam, 200 feet long, 12 feet maximum height.
33	Aaseconick Pond,	Hubbardston,	-	-	.60	133	-	-	Raised natural pond. Draft of 10 feet possible.
34	Reservoir north of Ropers Reservoir.	Hubbardston and Westminster.	-	Roper Lumber and Box Company.	2.80	80	6.0	10.5	Area estimated. Gravel dam, 75 feet long, 12 feet maximum height.
35	Ropers Reservoir,	Hubbardston,	-	Roper Lumber and Box Company.	4.10	42	16.0	14.0	Earth and stone dam, 150 feet long, 20 feet maximum height.
36	Natty Pond,	Hubbardston,	-	-	2.30	41	-	-	Low earth dam.
37	Phillipston Pond,	Phillipston,	-	-	.80	160	-	-	Numerous summer camps. Raised natural pond.

¹ Area from large scale plans or reliable local sources.

TABLE XVIII. — *Principal Lakes and Ponds on the Chicopee River in Massachusetts* — Concluded.

No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
	<i>Ware River — Con.</i>							
38	Sawyer Reservoir,	Templeton,	-	7.90	90	-	-	Earth and stone dam, draft formerly about 4 feet.
39	Browns Pond,	Phillipston and Templeton,	-	9.00	42	-	-	Earth dam, 120 feet long, 12 feet maximum height.
40	Williamsville Pond,	Hubbardston,	Seth Hale,	13.30	109	10.0	31.0	Earth dam, 200 feet long, 18 feet maximum height. Not drawn on at present.
41	Demond Pond,	Rutland,	Nagued Woollen Company,	2.60	57	6.0	13.0	Earth dam, 175 feet long, 8 feet maximum height.
42	Moulton Pond,	Rutland,	H. Calkins,	1.00	48	3.0	6.3	Earth dam, 200 feet long, 12 feet maximum height.
43	Long Pond,	Rutland,	Nelson D. White & Sons,	7.00	208	10.0	78.0	Earth dam, 200 feet long, 18 feet maximum height.
44	Muddy Pond,	Rutland and Oakham,	-	1.40	57	-	-	Natural pond.
45	Barre Reservoir,	Barre,	Barre Reservoir Company,	2.90	170	13.0	48.0	Earth dams, total length 750 feet, maximum height, 18 feet.
46	Hardwick Pond,	Hardwick,	-	15.00	99	-	-	Natural pond.
47	Pond north of Ware,	Ware,	-	19.30	29	-	-	-
48	Forest Pond,	Palmer,	-	3.90	63	-	-	Low wooden dam. Amusement park on shores.
49	Pottaquatic Pond,	Palmer,	-	.50	19	-	-	-
50	<i>Tributary below Three Rivers.</i> Springfield Reservoir,	Ludlow,	City of Springfield,	-	445	-	268.0	-



WESTFIELD RIVER.

The Westfield River and its four main branches drain a watershed of 515 square miles on the eastern slope of the Berkshires. The East Branch (169 square miles) joins the Middle Branch (53 square miles) about 2 miles north of Huntington. At Huntington these two are joined by the West Branch (96 square miles), and from thence the main river flows in a southeasterly direction a distance of about 23 miles to the Connecticut River, which it enters opposite Springfield. The Westfield Little River with its 84 square miles of drainage area comes in from the southwest just below Westfield, 10 miles above the mouth. The Boston & Albany Railroad follows the main river from Springfield to Huntington, and then the West Branch as far as Becket, a short distance beyond which it passes into the watershed of the Housatonic River.

The following are among the towns which are either wholly or largely in the Westfield watershed: —

NAME.	Pop-ulation in 1915.	NAME.	Pop-ulation in 1915.
Becket, ...	978	Plainfield, ...	375
Blanford, ...	633	Russell, ...	1,104
Chester, ...	1,344	Southwick, ...	1,365
Chesterfield, ...	559	Westfield, ...	18,411
Cummington, ...	660	West Springfield, ...	11,339
Huntington, ...	1,427	Windsor, ...	375
Middlefield, ...	325	Worthington, ...	618
Montgomery, ...	230		

Between the mouth of the river and Huntington there are eight paper mills, and one on the West Branch at Middlefield, but there are also a woolen mill at Huntington, three emery and corundum mills at Chester, and another between Huntington and Chester, a silk thread factory at Becket, and several small sawmills scattered over the basin, some of which manufacture small brush handles, saw handles, meat skewers, baskets, rattan, etc.

While primarily an agricultural region, the steep, rocky slopes necessarily confine the cultivated lands to the alluvial flats along the streams and the rounded uplands; but the steep hillsides are mostly covered with timber. There is a great deal of partly cleared timber land which may be brought under cultivation as time goes on, but with a few exceptions it appears to be rather poor farming land.

The mean annual rainfall on the basin is probably about 47 inches, which is greater than on the surrounding watersheds excepting those to the south.

The steep, rocky slopes of the Westfield and small amount of natural storage give rise to great and rapid fluctuations of flow. Twice during the summer of 1915 the water was so low at Woronoco at 10 A.M. that the mills had to run entirely by steam power, while by 7 P.M. the river had risen so high that the wheels had to be shut down on account of backwater. The greatest flood on record occurred Dec. 10, 1878, when 6 to 8 inches of snow fell on frozen ground, and was followed by rain and rapidly rising temperature, and, although the precipitation of rain and snow combined at Springfield was but 3.18 inches, the conditions were just right to produce a high rate of run-off. A great amount of damage was done throughout the valley, and particularly in the town of Westfield. A special committee appointed by the town engaged Hiram F. Mills as consulting engineer, and as a result of the investigation the dam at Westfield was lengthened 80 feet and the dike on the south side of the river raised. Mr. Mills estimated a maximum flow of 53,000 second-feet at Woronoco, or about 150 second-feet per square mile. At the Agawam dam at Mittineague the flow was 46,000 second-feet, or 90 second-feet per square mile. The greatest flow during the freshet of Aug. 4, 1915, at the Westfield gaging station, some 4 miles above the Agawam dam, was 17,400 second-feet, this being only 36.4 second-feet per square mile. In the 1878 flood the rise on H. E. Stanton's 260-foot dam on the East Branch at Huntington was between 12 and 13 feet, and the Boston & Albany bridge across the East Branch a short distance below was destroyed; but the ordinary spring floods do not cause a rise of more than 3 or 4 feet at this place. Since 1878 the disastrous effects of that flood have

been more or less forgotten, and there has been a tendency, particularly at Huntington and below Westfield, to build nearer and nearer the river, which suggests the fear that a similar flood at this time would do a tremendous amount of damage. While the valleys are so steep that the control of a sufficient drainage area by means of reservoirs to entirely prevent floods is out of the question, yet a series of four or five dams on the East Branch between Swift River and Huntington would be of very considerable benefit in smoothing off the crest of the flood waves, as described by Mr. Mills in his report, as follows: —

Every reservoir that the water fills in its course serves as a regulator which prolongs the time of flowing past any dam down the stream, but tends to decrease the amount passing at any moment. This is illustrated by the greatest quantity per second which is shown by the data of your survey to have passed the Salmon Falls Dam and the Agawam Dam, the former quantity being 53,000 cubic feet per second, and the latter, although increased by the drainage from 40 per cent. more area, but 46,000 cubic feet per second. This decrease in quantity, at the time of highest water, at the lower dam was due to a part of the water from above being used in filling the enormous reservoirs between the two dams, which drained off gradually after the flood had passed the upper dam.

Water Supplies.

The area of the watershed of the Westfield River that has been appropriated for municipal water supplies amounts to about 69 square miles, divided as follows: —

CITY OR TOWN.	Source of Water Supply.	Drainage Area of Water Supply.	Daily Consumption, 1918 (Gallons).
Springfield, ...	Westfield Little River, ...	48.0	10,710,000
Westfield, ...	Montgomery Reservoir and Tillotson Brook.	11.2	1,822,000
Russell, ...	Black Brook, ...	3.2	50,000 ¹
Holyoke, ²	Ashley Pond, ...	2.6	—
Huntington, ...	Cold Brook and Goldmine Brook, .	2.0	—
Chester, ...	Austin Brook and Horn Pond, . .	1.8	—
Worthington, ...	Springs, ...	—	1,600 ¹
Cummington, ...	Springs, ...	—	—

¹ Estimated.

² Other reservoirs on Manhan River.

In addition to the cities and towns named in this table Granville has a small supply, and the town of West Springfield has a system whose watershed is entirely within its own boundaries. The only water actually diverted from the Westfield watershed is that used by the city of Springfield and the small amount taken from Ashley Pond by Holyoke. The area of the watershed from which these diversions are made amounts to 50.6 square miles. During 1915 Springfield drew an average of about 16.5 cubic feet per second throughout the year, though at a somewhat greater rate during the summer than in the winter, requiring the entire low season flow of the Westfield Little River above the point of diversion, together with storage from the Borden Brook Reservoir. The capacity of the Springfield and Westfield systems can be greatly increased by the building of storage reservoirs, and surveys and general plans for such future extensions have been carefully considered by the two water departments.

Looking towards the future the size of the towns above Westfield will of necessity be so restricted by the topography of the valleys that it is improbable that the increase in population will be great enough to make the obtaining of sufficient water for municipal purposes a serious question. The country from Westfield to Springfield will probably depend upon the latter city by an arrangement similar to the metropolitan system, by which the city of Springfield will provide the surrounding towns with water from her Little River when their demands exceed the capacity of their present supplies. On this account the Westfield Little River should be considered as more or less dedicated to the city of Springfield, which in effect is actually the case to a considerable extent at the present time. Therefore, the proper development of this important branch of the Westfield River may be left to them.

Water Power.

Table No. XIX., pages 139 to 141, gives the details regarding the developed water power on the Westfield River. The total of the installed capacity of wheels at present is about 7,900 horsepower, of which 6,115 horsepower is located on the main river below the junction of the East and West branches at

Huntington, and 315 horsepower is on the East Branch at Huntington. By far the greater part of the power is used in the paper industry, as shown by the table referred to, and with the exception of a small amount of local lighting there is no electricity generated by water power for transmission.

The paper mills usually run twenty-four hours a day, and, as shown by the table, the size of the water-wheel installations is relatively low as compared with the other rivers of the State. With the exception of the Ramapogue Ice Company, which buys electric power from the Amherst Power Company, and a few of the very small sawmills the plants are all equipped with auxiliary steam plants.

It is doubtful if any of the mills, under their present method of operation, could obtain a sufficient amount of storage at a cost that would enable them to dispense with their auxiliary plants. However, with the extension of the high-tension transmission systems all over the State it is probable that purchased electric power will replace many of the steam auxiliary plants, and in this event the advantage of additional storage would be considerably greater than at the present time.

Undeveloped Water Power.

The estimated undeveloped water power on the Westfield River amounts to 33,244 horsepower. This estimate is made on the basis stated in the general summary, *i.e.*, by assuming water-wheel installations developing the mean flow of the river, which has been taken as 2.15 second-feet per square mile. This is divided among the branches, as shown by the following table: —

Undeveloped Water Power on Westfield River.

[Based on installations developing to mean flow assumed at 2.15 second-feet per square mile.]

BRANCH.	Horsepower.
Main River, ...	2,723
East Branch, ...	17,070
Middle Branch, ...	4,066
West Branch, ...	6,215
Westfield Little River, ...	3,170
Total, ...	33,244

It is impossible to estimate the value of this undeveloped water power from the information available. At the present time it appears doubtful if any of it could be profitably developed as an independent source of power, but the future course of events may make a very radical change in this situation. There have been several attempts in the past to develop hydro-electric energy for sale on the Westfield River, but in no case as yet has the prospect of profit been great enough to attract the capital required.

A brief description of the undeveloped stretches of the river is given below.

On the main river between Huntington and the mouth there is a total fall of about 300 feet, of which about 166 feet are at present in use, including the reservoir dam above Mittineague. The 136 feet of undeveloped fall are distributed along the river between plants, as shown on the attached profile. In only two places is it grouped together in sufficient amount to offer possibility of development.

The first of these is between Woronoco and Russell, where there is an undeveloped head of about 17 feet, which perhaps should be reduced by 3 feet to allow for flashboards at Woronoco.

The second possible site on the main river is at Turtle Mountain Bend, between Russell and the Chapin & Gould plant, which is a mile or so below Huntington. There is an undeveloped fall of 30 feet between the Chapin & Gould tail-water and the Westfield River Paper Company's pond at Russell. A corporation was formed and surveys and plans made for the development of this stretch of river a few years ago, but the matter has since then been dropped. The river is closely followed along both of these stretches by the Boston & Albany Railroad, whose tracks are only from 20 to 30 or 40 feet above the river, and seriously complicate the possibilities of development, as there is a very high rise in the river in times of flood, and ample provision for the handling of this flood water would have to be made.

There is also an undeveloped fall of 34 feet on the main river between Westfield and Woronoco, which occurs in a distance of 5 miles, but the valley is so wide that a very long canal or pen-

stock would be required, and therefore this fall has not been included in the figures for undeveloped power.

The largest part of the undeveloped water power on the Westfield River is on the East Branch from Stanton's Dam at Huntington to West Cummington, a distance of about 26 miles, with a total rise of 825 feet. In this stretch of the river there are only two privileges in use, one of 16-feet head at West Chesterfield, and another of 12-feet head at Cummington. Of this total fall, 370 feet are below West Chesterfield, and there are four fairly good dam sites along this part of the river at which a combined head of about 320 feet could be obtained, utilizing nearly all the fall between West Chesterfield and Stowell's Flats, which is about a half a mile above the mouth of the Middle Branch. It is also possible that some additional power could be developed at Norwich Bridge on the lower part of the river, where 16 feet were formerly obtained by means of a long canal.

From West Chesterfield the river runs north about 4 miles to Swift River, and then makes a right-angled turn to the west and extends 8 miles farther to West Cummington. There is an average slope of 42 feet per mile in the river between West Chesterfield and Swift River, and 36 feet per mile between Swift River and West Cummington, but it would require either long canals or pipe lines to develop these heads. From Swift River to West Cummington the stream is closely followed by a State road, which extends to Williamsburg and Northampton on the east, and to Dalton on the west, forming the main outlet of this region to the railroads; but between West Chesterfield and Swift River the river is entirely away from highways.

There are only three important tributaries on the East Branch, the first being the Dead Branch, which comes in above Knightville from Chesterfield and Bisbee, on which two proposed reservoir sites were surveyed, one at Lower Bisbee and one at Knightville. They have a drainage area of 16 square miles and a fall of over 500 feet between the two reservoirs, on which wheels of 1,410 horsepower could be installed. Presumably, this would be used during the summer only, so that in case of development a much larger installation would probably be put in. On the second tributary, the Little River, which

flows from Ringville and South Worthington down to the East Branch, which it joins at about the middle of the proposed Knightville Reservoir, there is also a total fall of 500 feet from the proposed reservoir above South Worthington to the Knightville flow line. This occurs in a distance of less than 3 miles, and the drainage area of 10 square miles would warrant an installation of 880 horsepower on the basis assumed. The third tributary is the Swift River. Assuming that a diversion dam is built a short distance below Lithia, at the junction of the Swift River and Stones Brook, where the drainage area is 23 square miles, a head of 150 feet could be obtained affording an installation of 607 horsepower. These developments on the tributaries of the East Branch would all be small, but surveys have been made for proposed reservoirs above them, and if built, the power developed would be available during the dry season, when the flow in the main river is at a minimum.

The Middle Branch of the Westfield River, with a long and narrow drainage area of 53 square miles, is not very promising for power development, as there is no natural storage and no good opportunities for storage reservoirs. The United States Geological Survey map indicates that the river has a uniform fall of about 50 feet per mile, which if utilized fully would yield 4,066 horsepower. The best dam sites on this branch are (1) at the so-called Millers Dam, just below the entrance of Den Stream Brook; (2) opposite the post office at North Chester; and (3) a quarter to one-half mile above the mouth of the East Branch, which was considered by the city of Springfield when it was investigating the use of this branch for its water supply. This site was also investigated by Mr. Percy M. Blake, who estimated that a reservoir of 50,000,000 cubic feet capacity could be built for \$200,000, or a cost of \$4,000 per million cubic feet.

The conditions on the West Branch are similar to those on the Middle Branch, with the added difficulty that the stream is closely followed by the Boston & Albany Railroad. However, the drainage area is somewhat larger, and the low flows are partly sustained by five reservoirs in Becket; but as they control an area of only 5.5 square miles, or less than 6 per cent. of the total of 96 square miles on this branch of the river, the

summer flows undoubtedly are very low. Between Huntington and Becket there is a total difference in elevation of 843 feet, of which only 67 feet are at present in use. The remaining 776 feet would maintain an installation of 6,215 horsepower.

Storage in Use.

Table No. XX. of lakes and ponds, on pages 142 and 143, shows the total storage in use at the present time on the Westfield River, and is estimated at 605,000,000 cubic feet, of which 473,000,000 cubic feet are contained in the Springfield, Holyoke and Westfield water-supply systems, while only about 132,000,000 cubic feet are stored for water power, 111,000,000 cubic feet of this being in the five Becket reservoirs. The Borden Brook Reservoir of the Springfield water-supply system is much the largest reservoir on the watershed, and was built in 1909 at a cost of \$211,000. A dam about 650 feet long and 70 feet high creates a reservoir with an area of 213 acres and a capacity of 343,000,000 cubic feet.

Of the five reservoirs referred to as in the town of Becket, four are tributary to the river above Becket Village. Two of these are controlled by the Bulkley Dunton Company, who have a mill at Middlefield, or Bancroft; and the other two are controlled by Mr. J. C. Ballou, who has two mills on the branch coming from the reservoirs above Becket. Water from the fifth reservoir enters between Becket and Bancroft, and is controlled by the Bulkley Dunton Company. These reservoirs are generally drawn on one at a time.

Norwich Pond, in Huntington, with a drainage area of about 1 square mile, was formerly controlled by the Chester Paper Company and drawn on to a depth of 8 to 10 feet, giving an estimated storage of 50,000,000 cubic feet. It has not been used since 1880, when the county commissioners insisted on repairs to the dam, which could be made at small cost, although considerable white birch that has grown up below the original high water line would have to be cleared. There are some 10 to 15 summer camps surrounding the lake, most of which are above the former high water line.

Windsor Lake at the upper end of the East Branch was also formerly used for storage by the L. L. Brown Paper Company's

mill at West Cummington, but six or eight years ago this plant was transferred to Adams, and since that time the lake has not been drawn on for storage. A depth of about 8 feet was available affording storage estimated at 23,000,000 cubic feet. The small dam at the outlet should be rebuilt if the lake is to be used again as a storage reservoir.

Possible Storage.

The investigation of the possibilities for increasing the storage on the Westfield River was confined to the East, West and Middle branches. As previously stated, the Westfield Little River has been acquired by the city of Springfield and plans made for its future development. When the city's demand exceeds the amount which the present storage in the Borden Brook Reservoir is able to supply during the dry periods, it is proposed to build a large storage reservoir on the Westfield Little River a short distance above the present diversion dam, at what is known as the Cobble Mountain Dam site, where it is proposed to build a dam 150 feet high in a rocky gorge, which will form a reservoir of 800,000,000 cubic feet capacity. The present system has been laid out in such a way that the water power created by this Cobble Mountain Dam can be made available. It is impossible to say how soon this reservoir will be required, but when built it should control the Westfield Little River above that point, as far as floods are concerned. With the increase in Springfield's consumption of water, more and more of the flow above the diversion dam will be removed from the watershed.

A relatively small amount of attention was given to the West and Middle branches, although both were examined in the course of the field reconnaissance, but the natural topography on these branches is not at all suited for the building of storage reservoirs. In addition, the existing developed head on which storage in either of these branches could be used is only 175 to 200 feet, and the prospects of this being increased by water-power developments on either of these branches appear remote.

Between the middle of April and the first of September, 1916, surveys were made of seven possible reservoir sites on the East Branch of the Westfield River, as shown in the following list:—

Reservoir Sites surveyed on Westfield River.

1. Knightville.
2. Lower Bisbee.
3. Upper Bisbee.
4. Below Ringville.
5. Spruce Corner.
6. North Branch, Swift River.
7. Meadow Brook.

Knightville. — By far the largest and most important reservoir site on the river is located about 5 miles above Huntington at the village of Knightville. Two miles below it is the excellent undeveloped power site at Stowell's Flats, where a head of about 60 feet can be developed, which, with the 175 feet of head at present in use below this point, and the 100 feet or so which could also be obtained in connection with the Knightville Reservoir, would make a total of 335 feet on which the stored water could be used.

The dam site that was considered is located near the school-house in the village of Knightville, a short distance below where the highway crosses from the east to the west side of the river. At this point the river flows through a rocky gorge, the solid ledge rising abruptly to a height of 70 feet on the west side of the stream. The rise continues on that side until an elevation nearly 110 feet above the level of the stream is reached, beyond which there is a slight depression before the high hills are reached. On the east side there is a narrow ridge of ledge some 60 feet high, beyond which the level of the ground falls to an elevation about 25 feet above the level of the water before the slope at the eastern end of the dam site is reached. Except for the narrow ridge next to the river no ledge appears at the surface on the east side of the stream.

The survey of this site extended to an elevation of 120 feet above the water level at the dam site, but at an elevation of 100 feet above the water level the total length of the dam would be about 1,150 feet, of which only about 400 feet would be anywhere near the full height. If raised to 120 feet above the water level the length would be increased by about 150 feet.

The basin thus formed would flood back between 5 and 7

miles to a point about 2 miles above the mouth of the Branch, and nearly up to the next good dam site on the It would cover an area of about a square mile, of which greater part is covered with timber which has been more or less cut off. There are 16 houses, 1 schoolhouse and from 40 barns, sheds and henhouses in the proposed reservoir. There would be flooded some fair farming land, two cemeteries containing about 400 and 200 headstones, respectively, and 8 miles of highway that would require relocation. The present road of gravel on a Telford foundation was constructed by the State in the summer of 1916, replacing an ordinary dirt road. A rough estimate shows that from 500,000,000 to 700,000,000 feet of storage could be obtained in the upper 20 or 30 feet of the reservoir, formed by a dam with the spillway crest at an elevation 100 to 110 feet above the present water level.

There is a tributary drainage area of 162 square miles at this point, and the run-off in times of high water would fill the reservoir in the course of a week. Therefore this amount of storage is far below the amount required to equalize the yearly run-off. However, a reservoir located at this point in the future would play a very important part in sustaining the low flow and the accompanying curve shows the effect of this storage as determined by a preliminary study. In connection with the reservoir a head of about 100 feet would be available for power, warranting an installation of 3,170 horsepower on the assumed run-off of the drainage area; but due to the location the capacity can always be used when required, therefore an installation of 5,000 or 6,000 horsepower would be desirable.

Bisbee Reservoir Sites. — Two sites were surveyed on the Dead Branch near the settlement known as Bisbee Mill in the town of Chesterfield. At the lower site, which is about a mile below Bisbee's sawmill, the drainage area is about 16 square miles, and conditions are very favorable for a dam 50 to 60 feet high. The valley is V-shaped, and ledge shows on one side of the river and also along the stream, and is probably not far below the surface on the other side. A dam 60 feet high would be about 500 feet long, and a low dike would be required on the west side of the stream. The height to which it would be desirable to raise the water here can be decided only after a more careful study of the situation.



III

The settlement at Bisbee Mill consists of a grist mill and feed store and a small sawmill, using the power from two water wheels which furnish about 50 horsepower on from 13 to 18 feet of head. There are also four or five houses with barns, half of which are above the highest flow line proposed, but if the water at the dam site is raised 60 feet some of the houses and barns will be affected, the water power will be entirely destroyed and the sawmill and feed store will have to be moved. It might, furthermore, be claimed that this flooding of the water power and sawmill would destroy the value of the remainder of the settlement. If the water is raised to this height it will back up-stream about 2 miles above the dam site to the second reservoir site, and will require raising the State highway, from Williamsburg to Chesterfield and West Chesterfield, 10 feet or more for a distance of about 1,500 feet. In order to obtain sufficient storage to entirely control the run-off above the dam site it will be necessary to raise the water to some such level as that suggested, but a lower dam causing less damage may prove desirable.

Outside of the damage to the Bisbee settlement and the highways the damage caused by this reservoir would be very slight. Some meadow land would be flooded, but the greater part of the land that would be flowed is swampy, and the extent of timber land not very great.

The highway which crosses the stream at Bisbee Mill would either have to be raised or abandoned, though its abandonment would not be a serious matter, as the State road is the one most largely used, excepting by the people at the mill, and is only half a mile above. This site is second only in importance to the Knightville site of all the sites on the Westfield River.

Upper Bisbee Site. — The second reservoir site on the Dead Branch is on the outlet of Burnell or Damon's Pond, and there are two possible locations for a dam. The first, or lower, is about half a mile above Bisbee Mill, just above where the State road from Chesterfield to Williamsburg crosses the stream. At this site there is a ridge running out from the east side about 30 feet high, which still leaves some 500 feet in the clear at the swamp level.

The upper site is at the highway above, which is but little used, and if the dam is built at the lower site the highway might well be abandoned. However, it appears from the survey that the upper site is much more desirable than the lower site, for although some reservoir area would be lost between them, the length of the dam required is less at the upper site, and furthermore, it could be raised to a greater height. At the lower site the ridge running out from the east would doubtless require considerable strengthening, and a dam higher than 30 feet would be out of the question. The survey was made with particular reference to building a dam at the upper site, with the flow line carried to an elevation of 40 feet above the water level at that point. The survey was carried up the river nearly to Damon's Pond, and covers a much larger basin than was indicated on the topographical sheet. Sufficient storage can be had at this point to completely control the run-off above, but as the drainage area is only 5 square miles, it is a question whether the full capacity to 40 feet elevation would be needed, unless there is some way by which water from the Dresser Pond Branch can be easily diverted into this reservoir.

Ringville Site. — This reservoir site is located on Little River about three-quarters of a mile above South Worthington, the dam site being just above where the road from South Worthington to Ringville crosses from the west to the east side of the stream. A survey was made covering the dam site and extending up-stream as far as Ringville, where there was formerly a small water power in connection with a sled factory not now in operation. The banks at the proposed site of the dam appear to be composed of sand and gravel with no ledge in sight, and as borings were not made it is impossible to say just how far below the surface solid rock will be found.

■ A dam such as proposed, with the flow line carried to an elevation 65 feet above the water level, would be about 1,000 feet long, and would flood the valley between the dam and Ringville, including the State highway between Worthington and Huntington, which was being made into a gravel road in the summer of 1916. The road would have to be relocated for a distance of about 2 miles, and in addition five houses, several barns and a small cemetery would be flooded. The land flowed is meadow land along the stream, with timber land containing considerable white pine on the sides of the valley.

Spruce Corner Site. — The Spruce Corner Reservoir site is on the Swift River, and the survey extended from a short distance above the village of Spruce Corner south about 2 miles. The dam site is near some abandoned farm buildings on the west side of the road, where there are also the foundations and ruins of an abandoned mill site. This is a fairly promising site, and is located at the lower end of a stretch of meadow land. Surveys previously made indicate that a dam raising the water level 42 feet would create a reservoir of 267 acres, and give 211,000,000 cubic feet of storage. The surveys made in the summer of 1916 were limited to taking the topography at the dam site and connecting same with the previous survey.

North Branch, Swift River. — The dam site is located on the North Branch of the Swift River about 1 mile above Swift River Village. The topographical map indicates that a dam raising the water level 40 to 50 feet would flood back nearly a mile and a half, and give about 100,000,000 cubic feet of storage, but a line of levels was run up the river and showed that a reservoir to this height would end about three-quarters of a mile up the river, which would make the volume of storage very much less than anticipated. Therefore, a rough survey only was made of the site.

Meadow Brook Site. — A rough survey was also made of a dam site where the highway crosses Meadow Brook about 1 mile north of Cummington. A dam of a maximum height of 40 feet would be something over 1,200 feet long, and a survey of the meadow above shows such a rapid rise that the volume of storage obtained would be small.

Other Sites. — In connection with previous investigations of the Westfield River, surveys have been made of the possibility of a reservoir on Stones Brook, and also on the branches of the river above West Cummington. Of these the most favorable is that on Stones Brook, where it appears that a dam 815 feet long at the water line, and 50 feet high to the spillway crest, would give a storage of 207,000,000 cubic feet. The other sites are not very promising, as in every case the storage is small for the height of dams required.

If it is necessary to obtain more storage on the Westfield River than that obtainable by means of the reservoirs already described, it may be desirable to investigate a location on the main stream about a mile above Cummington, where the con-

ditions somewhat resemble those at Knightville, although they are much less favorable. A dam 100 feet high at this place would have to be much longer than a dam at Knightville, and would not give as large a volume of storage, although by going to a sufficient height the water could be flooded back to West Cumming and give a very large storage; but it would require relocating the State highway between West Cumming and Cummington.

Conclusions regarding Storage on the Westfield River.

The three most favorable reservoir sites of those above mentioned are first, Knightville; second, Bisbee at a high level, taking the place of Lower and Upper Bisbee; and third, Spring Corner, — all to be operated primarily for the benefit of power at Knightville, but incidentally obtaining power from Bisbee under a 500-foot head at a second station to be located near the upper end of the Knightville Reservoir.

The hydrograph and time-flow curve at Knightville indicate a possible installation of about 8,000 horsepower at the two power stations at a total estimated cost of \$1,680,000.

It must be recognized that the conditions on this watershed are very unfavorable for the creation of storage at a low cost. The valleys are steep and trough-shaped, with the result that, generally speaking, high and long dams are required to store relatively small amounts of water.

At the present time some of the additional storage created could be used on but from 175 to 200 feet of head, and this is entirely too small to pay for its inevitably high cost. However, there is a considerable amount of undeveloped fall in the river, and if this could be developed it is quite probable that some of the reservoirs could be profitably built.

The two questions of the undeveloped water power and storage are closely linked together, because the development of the power requires a better sustained flow during the summer months, and the additional storage needs the extra developed fall.

In addition to the benefit to the water powers on the river there should also be mentioned the diminishing of the severity of floods. It is impossible to estimate the amount of damage which may be prevented in this way, but it might well amount to as much as the total cost of the work.



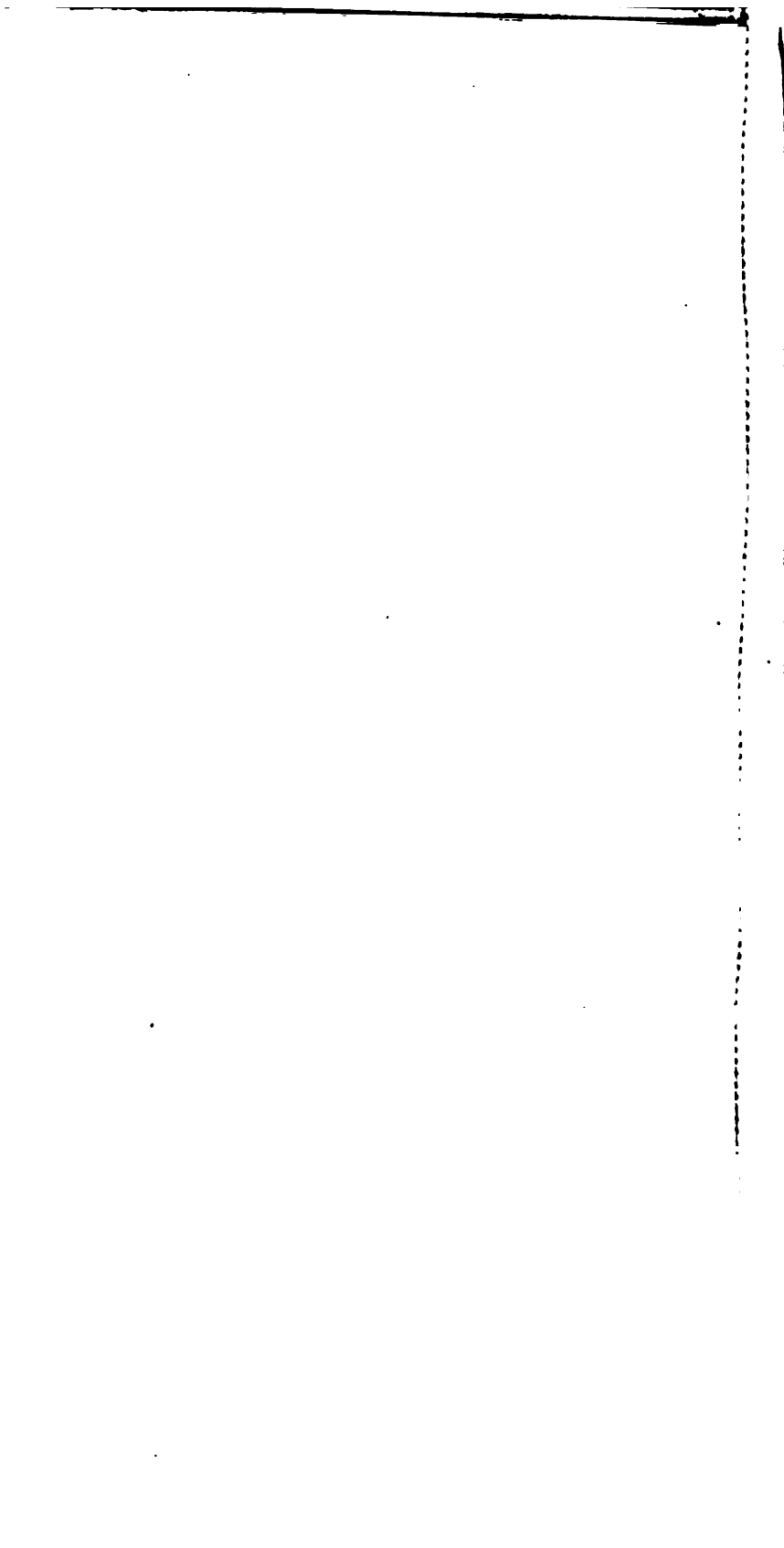


TABLE XIX. — *Water Power on the Westfield River in Massachusetts.*

(S. indicates steam; E., electricity; G., gas.)

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
1	<i>Westfield River (Mouth to Huntington).</i>										
	Worthy Paper Company, . .	Mittineague, . .	Paper, . .	24	513	9	110	98	18	S.	Entitled to 145 horsepower.
	Ramapogue Ice Company, . .	Mittineague, . .	Ice, . .	24	513	9	300			E.	-
	American Writing Paper Company, . .	Mittineague, . .	Paper, . .	24	512	37	929			-	-
2	Southworth Paper Company, . .	Mittineague, . .	Paper, . .	24	512	30	200	1.03	20	217 S.	-
	Strathmore Paper Company, . .	Mittineague, . .	Paper, . .	24	512	33	350			2,700 S.	-
	Reservoir dam, . .	Mittineague, . .	- . .	-	511	7	-	-	67	-	Used for storage only.
3	E. A. & S. A. Allen, . .	Westfield, . .	Miscellaneous manufacturing.	10	335	9	225	.72	10	225 S.	-
4	Strathmore Paper Company, . .	Woronoco, . .	Paper, . .	24	352	53	3,000	1.77	30	2,700 S.	-
5	Westfield River Paper Company, . .	Russell, . .	Paper, . .	24	312	22	500	.73	23	S.	-
6	Chapin & Gould Paper Company, . .	Russell, . .	Paper, . .	24	332	28	521	.64	10	540 S.	-

TABLE XIX. — *Water Power on the Westfield River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet Per Square Mile 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
7	<i>East Branch.</i> Chester Paper Company (A. W. P. Company).	Huntington.	Paper.	24	224	15	275	.90	5	175 S.	-
8	H. E. Stanton.	Huntington.	Sawmill.	10	224	11	40	.18	5	80 S.	Electric light plant 5 p.m. to 12 midnight; burn waste 5 a.m. to 7 a.m.
9	S. A. Heelys Sons.	West Chesterfield.	Saw handles.	10	99	16	70	.49	Small	30 S.	Burn waste.
10	Stevens Manufacturing Company.	Cumington.	Brush handles.	10	53	12	44	.76	Small	S.	Burn waste.
11	<i>Little River.</i> T. K. Higgins.	Worthington.	Baskets, etc..	10	10	14	55	4.32	Small	-	-
12	<i>Stevens or West Brook.</i> Stanton Manufacturing Company.	West Chesterfield.	Wood products.	10	12	39	75	1.76	Small	None	-
13	Charles Higgins.	West Chesterfield.	Baskets.	10	12	18	25	1.27	Small	21 G.	-
14	A. Stevens & Sons.	Worthington.	Hoops.	10	11	27	44	1.63	Small	None	-
15	<i>Dead Branch.</i> Horatio Blaboe.	Blaboe Mills.	Whip butts.	10	13	13	35	3.02	Small	None	-
16	J. C. Hammond.	Dresser Pond.	Whip butts.	10	3	18	18	9.80	Small	None	Power estimated.

[illegible]

TABLE XX. — *Principal Lakes and Ponds on the Westfield River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1: 30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
1	Ashley Reservoir,	Holyoke,	City of Holyoke,	2.50	281 ¹ .	—	114.0	Holyoke water supply.
2	Hampden Pond,	Westfield and Southampton.	—	2.20	149	—	—	—
3	Horse Pond,	Westfield,	—	2.90	34	—	—	—
4	Congamond Lake,	Southwick,	—	3.90	530 ¹	—	—	Berkshire Ice Company houses on west side of lake.
5	Borden Brook Reservoir,	Blandford,	City of Springfield,	7.95	213 ¹	—	334.0	Springfield water supply.
6	Blair Pond,	Blandford,	—	3.80	73 ¹	—	—	No artificial control exercised.
7	North Meadow Pond,	Blandford,	—	3.70	—	—	—	Has been drained. Land owned by city of Springfield.
8	Long Pond,	Blandford,	—	.75	58	—	—	—
9	Hassard Pond,	Russell,	Strathmore Paper Company,	—	71	—	—	Used for wash water.
10	Montgomery Reservoir,	Montgomery,	City of Westfield,	2.06	33 ¹	—	24.6	Westfield water supply.
11	Shatterack Pond,	Montgomery,	—	—	11	—	—	Natural pond. No artificial control.
12	Norwich Pond,	Huntington,	—	1.10	122 ¹	— ²	50.0	Operates as natural pond. Dam owned by Chester Paper Company. Not used.
13	Dedmun's Pond,	Chesterfield,	J. C. Hammond,	3.10	37 ¹	8	10.5	Sawmill just below.
14	Damon's Pond,	Chesterfield,	S. C. Damon Estate,	2.10	88 ¹	—	—	Used for boating and fishing.

	Windsor Pond,	Windsor,		2.00	79 ¹	- ²		Operates as natural pond. Dam owned by L. L. Brown Paper Company. Not used.
15	Windsor Pond,		-				-	
16	Crooked Pond,	Plainfield,	-	.35	33 ¹	4	3.5	
17	Horn Pond,	Becket,	-	.50	18	-	-	Chester water supply.
18	Middlefield Reservoir,	Middlefield,	-	8.80	-	-	-	Section of dam washed out in 1901. Not rebuilt.
19	Centre Pond,	Becket,	-	.90	112	6	21.0	Raised natural pond.
20	Rudd Pond,	Becket,	-	.80	80	8	18.0	Raised natural pond.
21	Ballou Reservoir,	Becket,	-	2.40	65	25	26.0	Reservoir created by dam. Maximum height about 39 feet.
22	Yokum Pond,	Becket,	-	.50	70	6	13.0	Raised natural pond.
23	New Reservoir,	Becket,	-	2.00	163	10	33.0	Reservoir created by dam. Maximum height about 13 feet.

¹ Area from large scale plans or reliable local sources.

² Can be raised 10 feet by repairing dam, giving 50,000,000 cubic feet storage.

³ Can be raised 8 feet by repairing dam, giving 18,000,000 cubic feet storage.

FARMINGTON RIVER.

The Farmington is the most important tributary entering the Connecticut River in the State of Connecticut. The river is formed by the East and West branches, both of which rise in Massachusetts and unite at New Hartford, Conn., after which the river flows southeasterly a distance of 25 miles to Farmington, where it makes a bend of nearly 180 degrees and thence pursues a winding course to the Connecticut River which it enters 5 miles above Hartford.

The total drainage area is about 600 square miles. The East Branch is the smaller of the two branches, and only the upper end of its watershed, amounting to 18 square miles, is in this State, in the town of Granville. The West Branch, however, rises in the town of Becket and pursues a southerly course for 17 miles through Otis, Tolland and Sandisfield to the State line at Colebrook, with a total fall of about 700 feet. The area tributary to the West Branch at the State line amounts to 103 square miles. All told there are 121 square miles of the Farmington watershed within this State.

The basin of the West Branch within this State is a wooded, thinly populated region. The following towns comprise the greater part of its watershed in Massachusetts: —

NAME.	Population in 1915.
Otis, ...	442
Sandisfield, ...	564
Tolland, ...	199

The slopes are steep and abrupt and the run-off is rapid. The mean annual precipitation is high, amounting to about 48 inches. There are no manufacturing industries in this State on the Farmington River excepting a few small sawmills. There are numerous summer camps and cottages on the shores of Otis Reservoir and Great Lake, or Big Pond.

In the State of Connecticut the Farmington River becomes quite an important stream, and a considerable amount of water

power is developed from it. The principal towns through which it passes in Connecticut are New Hartford, Collinsville, Unionville, Farmington, Tarriffville and Poquonock.

Water Power.

It can very nearly be said that there is no water power developed on the Farmington River in this State at the present time. There are about six small sawmills, as shown by Table No. XXI., on page 151, which run intermittently and employ but one or two men in each mill. The actual amount of power used in them is exceedingly small.

Throughout this State, and, in fact, the rest of the country, there has been a marked change in the use of small water powers during the last half century, and this change is nowhere better illustrated than on the Farmington watershed. Before a joint special legislative committee on western transportation facilities, which reported to the General Court in 1913, it was testified that at one time there were 71 mills in operation on the Farmington River above the Connecticut line. The entire western hill region was formerly fairly dotted with small grist mills, sawmills, chair and bedstead factories, woolen mills, etc., but the change to modern conditions, with larger mills and larger power requirements, together with increased transportation facilities and the development of steam and gasoline engines and electric power, have largely done away with these small water-power privileges, except where they are so located as to possess other advantages. The Farmington valley is entirely without transportation facilities except for the electric line recently built from Huntington to Lee, which runs across the upper end of the basin.

The topographical sheets of the United States Geological Survey constitute the chief source of general information available at present for estimating the undeveloped power on the Farmington River, although two reservoir sites were surveyed and will be discussed later. The total undeveloped power of the West Branch between North Otis and the State line amounts to 4,740 horsepower if estimated on the basis of a mean flow of 1.90 second-feet per square mile. The topographical map also indicates a fall of 200 feet between the Otis

Reservoir and the main stream, which would yield an additional 535 horsepower, making a total of 5,275 horsepower for the West Branch in this State.

Some thirty or forty years ago various mills on the river in Connecticut joined together to build the Otis Reservoir, located in Otis, Tolland and Blandford. A dam about 30 feet high and 600 feet long was built which flooded two natural ponds and made a large reservoir having an area of 1,064 acres, controlling a watershed of 17.6 square miles. A draft of 27 feet is obtainable, which gives a storage of about 800,000,000 cubic feet. Surveys were also made for raising Great Lake, or Big Pond, which is located a mile and a half north of Otis Reservoir, and is tributary to it. Some of the flowage rights were also bought up, but after the Otis Reservoir had been in operation for a while it was found that its capacity was large enough to control the flow above it, and the project of raising Great Lake was then abandoned.

The construction of additional storage reservoirs on the West Branch of the Farmington River is largely a question of finding a market for the power or the water that will justify the cost. The Otis Reservoir occupies the only really good site in this State, and there are no other tributaries of the West Branch that offer an opportunity for a storage reservoir of any size.

Two reservoir sites were surveyed on the West Branch, one at the village of North Otis and the other just above the State line at New Boston.

North Otis Site. — This is the upper site, about $1\frac{1}{2}$ miles above the village of Otis, with a drainage area of 16.8 square miles. The valley is comparatively narrow with not much tilled land, and a steep slope on the east but a more gradual slope on the west. Both slopes are well wooded having a coarse soil but no visible ledge at the dam site although it probably exists at no great depth.

A dam 65 feet high and 1,000 feet long will create a reservoir about $3\frac{1}{2}$ miles long and about 2,400 feet wide at its widest point, covering an area of 743 acres, with the flow line 60 feet above the present water level, which will give 804,293,750 cubic feet of storage.

The earth dam, spillway, reservoir site and removal of buildings will cost about \$235,000 on a pre-war basis of prices.

There are three ponds within the reservoir site. The lower pond of about 30 acres has a low dam at its outlet, and furnishes power for a small sawmill which will be flooded. The second pond is only a few acres in area, but the upper pond, known as Shaw Pond, covers 80 acres.

An assumed annual run-off of 25 inches over the net area of the watershed will produce about 906,000,000 cubic feet of water, which is about 100,000,000 cubic feet more than the capacity of the reservoir. It is therefore safe to assume that the reservoir will be filled at least once a year.

About $3\frac{1}{2}$ miles of new road will have to be built to replace the State highway which follows the stream for nearly the entire length of the reservoir. Some 22 houses and buildings are also within the flow line and will have to be moved.

New Boston Site. — This is the lower reservoir basin on which three dam sites were surveyed, the first just above the Connecticut line, and the second and third about $1\frac{1}{2}$ miles above this line. Dam No. 1 would have a height of 160 feet and a length of 1,400 feet, creating a reservoir about 3 miles long, with an area of about 523 acres, and a storage capacity of 1,228,000,000 cubic feet. Dam No. 2 would have a height of 110 feet and a length of 1,270 feet, creating a reservoir of about 344 acres with a storage capacity of 590,000,000 cubic feet. Dam No. 3 would have a height of 80 feet and a length of 900 feet, creating a reservoir of about 219 acres with a storage capacity of 295,000,000 cubic feet. Dams Nos. 1 and 2 would have to be built of stone or concrete masonry, as there is no opportunity for a side spillway, but Dam No. 3 could be an earth fill with provision for spillway on one side.

No estimates have been made of the cost of these dams, as the storage does not appear to be sufficient to justify their probable cost on our present knowledge of a market for the power.

The main highway follows the river throughout the entire length of the proposed reservoirs, and would have to be re-located. There are also a number of houses and buildings within the proposed basin which would have to be moved.

The valley of the West Branch is narrow with steep slopes, affording many good dam sites but small storage. Nevertheless, the power possibilities of this stream are interesting and worthy of further study, as there should be a market for the power in Connecticut if not in this State.

The best method of utilizing the flow of the stream is a question to be determined, but, as a suggestion, if a low dam were erected just below the junction of the outlet of the Otis Reservoir with the West Branch, and the flow conducted by a force main to a power site near the State line, a head of about 500 feet could be obtained which would develop from the watershed of the Otis Reservoir and the proposed reservoir at North Otis about 3,000 horsepower on a twenty-four-hour basis at 80 per cent. efficiency, using an assumed mean run-off of 1.9 second-feet per square mile of watershed. The force main would be about 8 miles long, but no estimate has been made of its cost.

Table No. XXII., on page 152, shows the principal lakes and ponds on the watershed of the Farmington River in this State.

As previously noted, the principal use of the Farmington River is in Connecticut, and in 1909 the city of Hartford, Conn., petitioned the General Assembly of that State for authority to appropriate the waters of the Nepaug River and Phelps Brook, two tributaries of the Farmington in Connecticut which enter it in the vicinity of Collinsville.

Due to the opposition of the power owners on the river below, who claimed that the taking of these streams would so deplete the flow of the main river as to cause irreparable damage to their interests, this petition was denied by the General Assembly.

However, an expansion of the city's water supply was absolutely necessary, and the matter was amicably adjusted between the mills and the city by an agreement on the part of the city to construct a compensating reservoir on a large tributary of the Farmington River, farther up-stream. This was to be used for the benefit of the mills in lieu of the water diverted from Nepaug River and Phelps Brook by the city. In 1911 the General Assembly was again petitioned and the required legislation secured.

The city then proceeded to acquire the necessary land, but the owner of one large and important property fought the condemnation proceedings in the courts, and carried his case through the State courts and up to the United States Supreme Court. This court gave final judgment in favor of the city on April 17, 1916.

The following statement of the points at issue is taken from a description of this case by Caleb Mills Saville, chief engineer of the Hartford Water Works, in the "Engineering News" of Aug. 10, 1916, from which the brief summary above is also taken. This decision may prove of considerable importance in case the Commonwealth of Massachusetts desires to authorize the building of reservoirs with rights of condemnation of the land required therefor.

The respondents demurred to the appointment of appraisers on the following grounds: that the water of the compensating reservoir was not for the use of the city of Hartford; that the city was not required but simply authorized to return water to the river; that the maintenance of the flow of the river was not a public use but a private benefit to lower riparian owners; that the real purpose of the compensating reservoir was to enable the city of Hartford to trade off the impounded water in lieu of paying money damages; that such a purpose was uncertain of accomplishment because lower riparian owners would be legally entitled to take their compensation in money; that the resolution, in so far as it purported to take the respondent's land for the purposes of a compensating reservoir, was in violation of the Constitutions of Connecticut and of the United States.

This demurrer was sustained by the judge of the Superior Court, but on appeal the Supreme Court of Errors of the State overruled the decision, holding that the taking was for a public use and not contrary to the Constitution of the State or of the United States (87 Conn., 193 *et seq.*), and remanded the case to the Superior Court to be proceeded with according to law. Under this ruling appraisers were appointed to establish the value of the land. Appeal was again made to the Supreme Court on points of law. This appeal was not sustained. Application was then made to the Supreme Court of the United States for a writ of *supersedeas*, and it was ordered issued by Associate Justice Charles E. Hughes, Feb. 10, 1916, three and a half years after proceedings were begun.

What constitutes a "public use" was the single Federal question involved. From the nature of the case this can be neither definite nor fixed, but must depend upon that which the public necessity, convenience or the welfare of society at a particular time may demand. To quote again: —

What is public use? Our historical research discloses the meaning of the term "public use" to be one of constant growth. As society advances, its demands upon the individual increase, and each demand is a new use to which the resources of the individual may be devoted (*Tuttle v. Moore*, 3 Ind. Ter. 712).

The definition of the term "public use" for which land may be appropriated should comprehend not only all existing public purposes justifying such appropriation, but should anticipate the further exigencies of society, demanding new laws and varied exercise of the protecting and fostering aid to the State (*Concord Railroad Co. v. Greely*, 17 N. H. 47).

In the brief for the petitioners the following different classes of "public use" were given:—

1. When the United States, a State or a municipal corporation seeks to acquire a parcel of land on which to carry out its proper public functions, or to perform some act directly enhancing the security or health of the community, as taking land for forts, schoolhouses, etc.
2. When the public is supplied with some commodity or convenience, as takings for railroads, water supplies, parks, etc.
3. When individual members of the public are enabled to cultivate their lands or carry on their business to better advantage, as construction of dams, building of levees, swamp and irrigation districts.

The opinion of the Supreme Court of Errors of Connecticut, sustained by that of the Supreme Court of the United States, while not establishing the principle of compensation in kind in lieu of money damages, does sanction the taking of land by eminent domain for the purpose of conserving waste waters and returning them to a stream, and it also holds that such action is for "public use" and not a violation of the Constitution of the State of Connecticut or that of the United States.

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This judgment plainly shows that the right of State Legislatures to condemn lands under eminent domain rests on the broad principle of public benefit, irrespective of how few there are who avail themselves of the privilege.

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TABLE XXI. — *Water Power on the Farmington River in Massachusetts.*

No.	NAME OF COMPANY.	Location.	Product.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Area of Pond (Acres).
1	Ivers, ...	Tolland, ...	Sawmill, ...	96	14	40 ¹	Small
2	Deming, ...	Sandisfield, ...	Sawmill, ...	91	10	40 ¹	Small
3	Clark, ...	New Boston, ...	Sawmill, ...	59	17	70	Small
4	D. A. Witter, ...	Otis, ...	Sawmill, ...	19	11	40 ¹	Small
5	Kaufman, ...	North Otis, ...	Sawmill, ...	14	10	30 ¹	Small
6	G. L. Thomas, ...	Above North Otis, ...	Sawmill, ...	4	8	18	-
	Total, ...	-	-	-	-	238 ¹	-

¹ Power estimated.

TABLE XXII. — *Principal Lakes and Ponds on the Farmington River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Shaw Pond, ...	Otis and Becket,	Natural lake, ...	4.0	100 ¹	—	—	—
2	White Lily Pond, ...	Otis, ...	—	—	40	—	—	—
3	Pond west of White Lily Pond, Great Lake, or Big Pond, ...	Otis, ...	—	—	29	—	—	—
4	Otis Reservoir, ...	Otis, ...	Natural lake, ...	6.9	310	—	—	33 camps on shores.
5	Parish Pond, ...	Otis, ...	Farmington Water Power Company, ...	17.2	1,065 ¹	27	880	Two ponds raised by earth dam 600 feet long, 30 feet high.
6	Larkum Pond, ...	Otis, ...	—	—	48	—	—	—
7	Spectacle Pond, ...	Otis, ...	—	—	10	—	—	—
8	Simon Pond, ...	Sandisfield, ...	—	2.8	60	—	—	—
9	Noyes Pond, ...	Sandisfield, ...	—	1.5	76	—	—	—
10		Tolland, ...	—	1.4	181	—	—	—

¹ Area from large scale plan or reliable local sources.

HOUSATONIC RIVER.

The Housatonic River is formed in Pittsfield by the union of its East, West and Middle branches. From thence it flows in a southerly direction about 125 miles across Massachusetts and Connecticut to Long Island Sound, which it enters about 4 miles east of Bridgeport. The total drainage is about 1,930 square miles. The area tributary at the Massachusetts-Connecticut boundary line is 532 square miles, of which 12 square miles are in Connecticut and 33 square miles in New York State.

The river runs through a beautiful valley flanked much of the way by wooded hills, with now and then a bordering of alluvial meadow land, and, as compared with the other streams in Massachusetts west of the Connecticut River, its basin is open with relatively flat slopes. In places the immediate valley along the stream attains a width of 2 or 3 miles, and all told that part in Massachusetts contains a considerable amount of very good farming land.

In general, the entire watershed within this State might be spoken of as one large summer resort. It is to this region that the term "the heart of the Berkshires" is applied.

The following table shows the principal cities and towns in the basin in Massachusetts:—

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Alford, ...	271	Monterey, ...	358
Dalton, ...	3,858	New Marlborough, ...	1,030
Egremont, ...	590	Pittsfield, ...	39,607
Great Barrington, ...	6,627	Richmond, ...	564
Hinsdale, ...	1,257	Sheffield, ...	1,882
Lanesborough, ...	1,089	Stockbridge, ...	1,901
Lee, ...	4,481	Tyringham, ...	327
Lenox, ...	3,242	West Stockbridge, ...	1,277

Pittsfield is the principal city in the basin, with a population of nearly 40,000. A considerable amount of manufacturing is carried on here, the development of which has been almost entirely independent of water power. Above and below Pittsfield there is a certain amount of manufacturing distributed along the river. This consists largely of paper and woolen mills, which in most cases were originally attracted to their locations by the water power of the river. Due to the manufacturing waste discharged into the river, particularly that from the paper mills, the water of the river is highly polluted.

While the river is not as subject to such sudden and great rises as are the Westfield and Deerfield rivers, yet at times considerable annoyance and some damage is caused. The situation is somewhat different from that on the other two rivers mentioned. On them the floods are caused by the steep and rocky slopes which shed their water in torrents, while on the Housatonic River the valley is so flat that the trouble is chiefly caused by the length of time required for the water to run off.

Water Power.

Table No. XXIII., on pages 159 to 161, gives the list of the developed water powers on the Housatonic River within the State of Massachusetts. The total developed head between Pittsfield and the State line is about 210 feet, while on the East Branch above Pittsfield an additional 325 feet are in use. The total installed wheel capacity amounts to nearly 12,000 horsepower, of which 6,743 horsepower is used by various paper mills, in which the Dalton Power Company is also included, and 4,066 horsepower in the textile mills. That portion of the river in the State of Connecticut is much more important from a water-power standpoint. The stream has a total fall of 645 feet between the State line and Long Island Sound, of which about 250 feet have been developed and are in use. The two largest developments are at Falls Village and Bulls Bridge, where water wheels of 15,000 and 10,500 horsepower, respectively, are installed. Of the remaining 395 feet in Connecticut a considerable part can doubtless be developed if the cost of power should warrant it.

The accompanying profile shows the distribution of the de-

veloped and undeveloped stretches of the river within this State. Between Pittsfield and the State line there is a total fall of 314 feet, of which 104 feet are not at present in use. This 104 feet is so distributed along the river that it is doubtful if any of it could be considered as a separate privilege.

Storage.

Table No. XXIV., on pages 162 and 163, shows the principal lakes and ponds of the Housatonic River Basin within this State, with estimates of the storage capacity of those used as storage reservoirs. At the present time there are eight which might be said to be so used in addition to the reservoirs used for municipal water supplies. A ninth reservoir, Richmond Pond, was formerly drawn on for storage, but is not made use of at present. The eight reservoirs have an estimated total capacity of 537,000,000 cubic feet and a combined drainage area of 63 square miles.

In regard to the question of additional storage on the Housatonic River, the following statement regarding this stream was made in the 1880 water-power census: —

Much has been done to improve the storage of the natural ponds by raising their surfaces by dams, and some entirely artificial reservoirs have also been built; undoubtedly the work might be carried on further on some of the tributaries, but it is the opinion of good judges that the reservoir capacity of the upper river has been developed about as much as is really practicable.

This statement is even more true to-day than at the time it was made.

The main river and the principal branches of the Housatonic River are closely followed by railroads with towns located at short intervals, and with valuable farming land of varying widths bordering the stream. In no case are the conditions such that a reservoir could be created giving a large amount of storage without seriously affecting railroads and towns. Below is given a description of the possible reservoir sites with reasons for considering them unfavorable.

If any additional storage to be created is to be of much use to the mills within this State, this storage must be obtained

either above or just below the city of Pittsfield. As previously stated, below Pittsfield there is a total of about 210 feet of developed head north of the Connecticut line, with an additional 250 feet within the State of Connecticut. Considering now the possibilities of storage above the city of Pittsfield, the only place on the East Branch of the Housatonic where the topography is such as to make the creation of a reservoir possible is just above the Hinsdale station on the main line of the Boston & Albany Railroad. At this point the drainage area is 24 square miles, of which 7 square miles are at present under control by Ashmere Lake and the Plunkett Reservoir. Just above the Hinsdale station there is a large area amounting to nearly 1,000 acres, part of which is fair farming land and part brush and scrub timber land. It would be possible to construct a dam not over 700 to 900 feet long which would flood this meadow to a depth of 15 to 20 feet. The main line of the Boston & Albany Railroad extends along one side of it, and would be flooded for a distance of from 3 to 4 miles. There are three tracks the entire distance, and at the lower end they branch out to seven and eight for the switching yards above Hinsdale. This is at the upper end of the steep grade east of Pittsfield. It is doubtful if the Boston & Albany Railroad Company would consent to the disturbance of their tracks under any conditions, and it is also doubtful if the volume of storage obtainable would be sufficient to warrant the cost of relocating or raising the tracks. In addition, 1,000 acres or more of what may some day be turned into the finest farming land would be destroyed for agricultural purposes.

On the Middle Branch of the Housatonic River the increase of storage is limited to raising Pontoosuc and Onota lakes. As far as the physical conditions are concerned, both could be raised from 10 to 15 feet, 10 feet adding about 240,000,000 cubic feet to Pontoosuc Lake, and 275,000,000 cubic feet to Onota Lake.

In the case of Pontoosuc Lake this would mean heavy damages due to flooding from 30 to 50 summer camps and cottages which literally surround the lake. In addition, the Berkshire Street Railway Company's electric line follows the east side of the lake for a distance of about a mile, and for the

greater part of this distance it is only from 3 to 8 feet above the present high water level. Pontoosuc Lake is also the popular resort of the city of Pittsfield, and there is no doubt but that its value for pleasure purposes is much greater than would be the increased storage. On account of the rapid growth of Pittsfield, land values throughout the surrounding region are exceedingly high; therefore it would appear to be out of the question to consider increasing the storage of Pontoosuc Lake.

The conditions at Onota Lake are somewhat more favorable, as there are not nearly as many cottages, nor is the lake as extensively used. The drainage area, however, is only 10 square miles, so that any additional storage above that already existing could be used but once a year. The use of this lake for storage might be complicated by the fact that it is drawn on by the city of Pittsfield for its water supply during the low water periods. A small amount of additional storage might be obtained here, but in view of the above facts the cost of further investigation would not be justified unless there was more prospect of obtaining a considerable amount of storage.

On the West Branch there is something like 45,000,000 cubic feet of storage that can be had in Richmond Pond by repairing the dam and using it to its full capacity. The cost of these repairs would not be large. The Sprague Ice Company have large ice houses located on the shores of Richmond Pond between it and the tracks of the Boston & Albany Railroad. The lake is held to its present level by a low earth dam about 1,500 feet long, the greater part of which is not more than 4 to 6 feet high, but the level is so near that of the Boston & Albany tracks, and the length of the dam so great, that it is hardly practicable to increase the storage.

Passing down the main river below Pittsfield the possibility of a reservoir at Lenox station, some 8 miles below, was considered. At this point a dam from 600 to 800 feet long could be built that would raise the water level about 25 feet, flooding back to Pittsfield and giving about 600,000,000 cubic feet of storage, according to the topographical map. The profile of the river showed, however, that such a dam would flood a part of Pittsfield in addition to affecting about 4 miles of the Housa-

tonic branch of the New York, New Haven & Hartford road, as well as a mile or more of the Berkshire Street Rail Company's tracks, and hence its construction would be out of the question.

There is also an open stretch of country on the main road above South Lee which could be flooded by a dam a short distance above where the New York, New Haven & Hartford road crosses the river. The water could be raised 30 feet without affecting the lowest privilege at Lee, but it would almost certainly flood a part of the village of East Lee, and the water which would be flowed is all of the finest quality for farming.

The topography of the valley below here is such as to make the creation of any large storage reservoir along the main river impossible. As to the tributaries that enter below Pittsford Hop Brook, which comes in just above South Lee, contains the possibility in Tyringham. A dam could be built about a half mile above the center of the village at a point where the road crosses the stream, which if built to a height of 50 to 60 feet would form a reservoir having a capacity of 250,000,000 to 300,000,000 cubic feet, according to the topographical map. The greater part of this land is meadow land, but not of so great value as that along the Housatonic River.

The use of Stockbridge Bowl, in the town of Stockbridge, is precluded by the value of the land surrounding it, which forms a part of the estates of wealthy summer residents. In addition, an extremely long dam would be required to add materially to the storage.

Conclusions.

While the large amount of developed and undeveloped farmland on the Housatonic River makes any increase in the storage of the basin highly desirable, the natural topography of the basin is such that when considered in connection with the location of the towns and railroads the creation of this storage becomes too costly to be feasible. It may be that small amounts of storage can be created at various places that would be of considerable benefit to powers located directly below them, but when it comes to the creation of a comprehensive system of storage reservoirs large enough to materially affect the flow of the main river, one is forced to the conclusion that the cost would be too great.

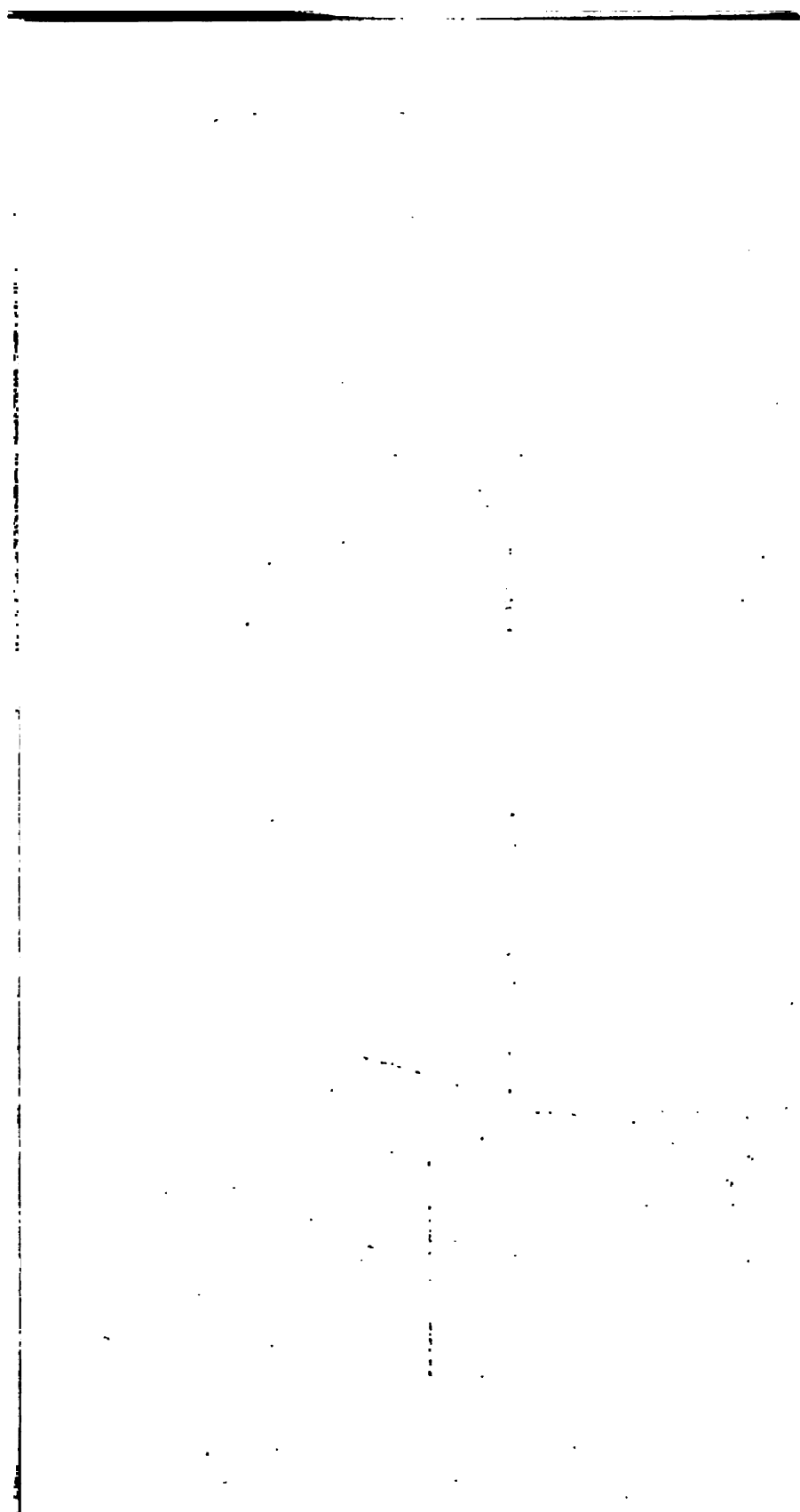


TABLE XXIII. — *Water Power on the Housatonic River in Massachusetts.*

[S. indicates steam; E., electricity.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
1	Great Barrington Electric Light Company.	Great Barrington.	Electricity.	24	332.0	10	339	1.12	21.0	180 S.	-
2	B. D. Rising Paper Company.	Housatonic.	Paper.	24	279.0	22	1,200	2.16	43.0	-	-
3	Monument Mills.	Housatonic.	Cotton goods.	9	278.0	10	260	1.03	4.3	S.	-
4	Monument Mills.	Housatonic.	Cotton goods.	9	278.0	18	485	1.07	29.0	S.	-
5	Monument Mills.	Glendale.	Cotton goods.	9	277.0	20	750	1.49	96.0	-	Hydro-electric plant.
6	Monument Mills.	Glendale.	Cotton goods.	9	274.0	40	1,500	1.51	76.0	-	Hydro-electric plant.
7	American Writing Paper Company.	South Lee.	Paper.	24	244.0	19	500	1.19	18.0	350 S.	-
8	Eaton-Dikeman Company.	Lee.	Paper.	24	187.0	10	300	1.76	4.7	400 S.	-
9	Smith Paper Company.	Lee.	Paper.	24	183.0	10			22.0	S.	Eagle Mill.
10	Smith Paper Company.	Lee.	Paper.	24	183.0	15			28.0	S.	Columbia Mill.
11	Smith Paper Company.	Lenoxdale.	Paper.	24	170.0	12	2,000	2.20	2.3	S.	-
12	Smith Paper Company.	Lenoxdale.	Paper.	24	170.0	10			13.0	S.	-
13	Smith Paper Company.	Lenox station.	Paper.	24	168.0	10			156.0	S.	-

TABLE XXIII.—*Water Power on the Housatonic River in Massachusetts*—Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-foot per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
<i>East Branch, Housatonic River.</i>											
14	C. A. Burbank, . . .	Pittsfield, . . .	Electricity, . . .	10	69.0	12	125	1.66	41.0	-	Sells power to Pittsfield Electric Company.
15	Crane & Co., . . .	Pittsfield, . . .	Paper, . . .	24	57.0	14	200	2.76	6.0	600 S.	-
16	Z. & W. M. Crane, . . .	Dalton, . . .	Paper, . . .	24	56.0	26	300	2.26	12.0	S. and E.	-
17	Crane & Co., . . .	Dalton, . . .	Paper, . . .	24	55.0	14	200	2.80	1.5	550 S.	-
18	Old Berkshire Mills Company, . . .	Dalton, . . .	Paper, . . .	24	55.0	23	107	.99	1.8	E.	-
19	Sawyer Ragan & Co., . . .	Dalton, . . .	Woolens, . . .	24	54.0	-	-	-	3.4	-	-
20	Byron Weston Company, . . .	Dalton, . . .	Paper, . . .	24	53.0	22	320	3.02	1.6	-	-
21	Byron Weston Company, . . .	Dalton, . . .	Paper, . . .	24	53.0	19	288	3.15	27.0	-	-
22	Dalton Power Company, . . .	Dalton, . . .	Electricity, . . .	24	27.0	22	160	2.78	-	-	Hydro-electric plant.
23	Dalton Power Company, . . .	Hinsdale & Dalton, . . .	Electricity, . . .	24	26.0	152	1,000	2.79	7.0	-	Hydro-electric plant. Total head 188 feet.
24	Hinsdale Woolen Company, . . .	Hinsdale, . . .	Woolen goods, . . .	9	24.0	-	-	-	-	-	-
25	Hinsdale Woolen Company, . . .	Hinsdale, . . .	- . . .	-	24.0	-	-	-	-	-	Pondage only (?)
<i>West Branch.</i>											
26	W. E. Tillotson, . . .	Pittsfield, . . .	Woolens, . . .	9	19.6	7	-	-	-	-	-
27	W. E. Tillotson, . . .	Pittsfield, . . .	Woolens, . . .	9	19.3	-	-	-	-	-	-
28	Shaker Mill, . . .	West Pittsfield, . . .	Grist mill, . . .	-	10.3	26	39	1.56	-	10 S.	-

Middle Branch.		Onota Brook.		Williams River.		Goose Pond Brook.		Greenwater Pond Brook.		Kankakee River.		Total.	
29	Eaton, Crane & Pike Company.	Pittsfield.	Woolens.	9	37.0	9	116	3.84	15.0	E.	-	-	-
30	James & E. H. Wilson.	Pittsfield.	Woolens.	9	23.0	23	160	3.32	5.7	400 S.	{ Belair Mill. Taconic Mill.		
31	James & E. H. Wilson.	Pittsfield.	Woolens.	9	23.0	23	180	3.74	-	700 S.	At outlet of Pontonac Lake.		
32	Pontonac Woolen Manufacturing Company.	Pittsfield.	Woolens.	9	22.0	20	200	5.00	505.0	-	Water wheels eliminated.		
33	S. N. & C. Russell Manufacturing Company.	Pittsfield.	Woolens.	9	11.1	-	-	-	-	-	At outlet of Onota Lake.		
34	Berkshire Woolen and Worsted Company.	Pittsfield.	Woolens.	9	10.6	29	200	7.16	19.0	S.	Local electric lighting.		
35	Berkshire Woolen and Worsted Company.	Pittsfield.	Woolens.	9	10.4	21	108	5.44	555.0	S.	Total head 190 feet.		
36	Rockdale Mills.	Rockdale.	Grist mill.	-	39.0	25	60	.68	-	None	-		
37	Shaker Grist Mill.	West Stockbridge.	Grist mill.	-	33.0	13	80	2.05	-	None	-		
38	H. C. Clark & Son Machine Company.	East Lee.	Machine shop.	10	13.6	12	-	-	-	-	-		
39	Lee Electric Light Company.	East Lee.	Electricity.	24	13.6	36	120	2.70	-	-	-		
40	Mountain Mill Paper Company.	East Lee.	Paper.	9	13.5	12	35	2.33	-	E.	-		
41	Mountain Mill Paper Company.	East Lee.	Paper.	24	5.3	185	240	2.81	-	250 S.	-		
42	E. Dowd.	East Lee.	-	-	7.0	14	24	2.70	-	-	-		
44	Whitney Brothers.	Hartsville.	Sawmill.	-	25.0	9	25	1.22	-	-	-		
				-	-	-	11,690	-	-	-	-		

TABLE XXIV. — *Principal Lakes and Ponds on the Housatonic River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
1	Muddy Pond, .	Washington and Hinsdale,	-	1.5	43	-	-	-
2	Plunkett Reservoir, .	Hinsdale, .	Ashmere Reservoir Association,	2.7	74 ¹	20	45	Earth dam about 550 feet long, and 23 feet maximum height.
3	Ashmere Lake, .	Hinsdale, .	Ashmere Reservoir Association,	4.3	184	20	54	Earth dam about 1,000 feet long, and 30 feet maximum height.
4	Windsor Reservoir, .	Windsor and Peru, .	Mills in Dalton, .	14.7	62	30	40	Arched masonry dam, 38 to 40 feet high.
5	Goodrich Pond, .	Pittsfield, .	-	3.8	33	-	-	-
6	Silver Lake, .	Pittsfield, .	-	1.2	23	-	-	Used mainly for condensing water.
7	Pontotoc Lake, .	Pittsfield and Lanesborough, .	Pontotoc Woolen Company, .	21.7	505	7	138	Masonry dam, 16 feet high, 75 to 80 feet long. Many summer camps.
8	Onota Lake, .	Pittsfield, .	Berkshire Woolen and Worsted Company, .	10.4	685 ¹	5	104	Natural lake raised 5 feet. Many summer camps.
9	Richmond Pond, .	Pittsfield and Richmond, .	-	7.3	219	-	-	Long earth dam. Could be drawn 5 to 10 feet if dam and gate repaired.
10	Ashley Lake, .	Washington, .	City of Pittsfield, .	.8	111 ¹	-	-	Pittsfield water supply.
11	Farnham Reservoir, .	Washington, .	City of Pittsfield, .	1	42 ¹	-	-	Pittsfield water supply. Dam, 110 feet high.
12	Clapp Pond, .	Washington, .	City of Pittsfield, .	2.7	12	-	-	Pittsfield water supply.
13	Laurel Lake, .	Lenox and Lee, .	Smith Paper Company, .	3.0	165 ¹	6	35	Earth dam about 275 feet long, 15 feet high. Used for wash water.
14	Greenwater Pond, .	Becket, .	Greenwater Pond Company, .	1.6	90	3	16	Draw-down estimated.

15	Goose Pond,	Lee and Tyringham,	Goose Pond Company,	4.3	194	15	108	Natural pond raised by earth dam 300 feet long, 25 feet high. Water level controlled to some extent by Goose Pond dam.
16	Upper Goose Pond,	Lee and Tyringham,	Goose Pond Company,	1.2	46	-	-	Natural pond. Abandoned mill pond at Curtisville flows back to lake.
17	Stockbridge Bowl,	Stockbridge,	-	10.3	377	-	-	Stockbridge water supply. Low earth dam.
18	Lake Averio,	Stockbridge,	Stockbridge Water Company,	2.2	40 ¹	-	-	
19	Shaker Mill Pond,	West Stockbridge,	-	32.8	68	-	-	
20	Crane Pond,	West Stockbridge,	-	-	30	-	-	
21	Mud Pond,	West Stockbridge,	J. F. Bosidy,	-	84	-	-	These four ponds used for pondage for grist mill and local electric light plant.
22	Cranberry Pond,	West Stockbridge,	-	-	20	-	-	
23	Long Pond,	Great Barrington,	-	1.4	100	-	-	Great Barrington water supply.
24	Prospect Lake,	Egremont,	-	1.8	55	-	-	
25	Marsh Pond,	Egremont,	-	1.6	25	-	-	
26	Mill Pond,	Sheffield,	-	25.2	80	-	-	
27	Lake Garfield,	Monterey,	Town of Monterey,	3.8	272	-	-	Earth dam. Water rights purchased and presented to town in 1913.
28	Lake Buel,	Monterey and New Marlborough,	-	4.8	196 ¹	-	-	Natural pond. Numerous summer camps.
29	Harmon Pond,	New Marlborough,	-	.6	21	-	-	
30	East Pond,	New Marlborough,	-	1.7	65	-	-	

¹ Area from large scale plans or reliable local sources.

HOOSAC RIVER.

The Hoosac River drains the northwestern corner of Massachusetts and is formed at North Adams by the union of the South and North branches. From this point it flows in a northwesterly direction past Williamstown to the Massachusetts-Vermont boundary line, and after crossing the southwestern corner of Vermont continues in New York State and becomes one of the most important tributaries to the Hudson River, which it enters at Mechanicsville. Its total drainage area is 710 square miles. At the Massachusetts-Vermont boundary line the tributary area is 204 square miles, of which 39.5 square miles are in Vermont.

The Hoosac Valley in this State is fairly open adjacent to the stream, and contains a considerable proportion of good agricultural land. The hills flanking the valleys rise to a considerable height, the Hoosac Range which is pierced by the Hoosac Tunnel forming the divide between the Hoosac and Deerfield rivers, while Mount Greylock, the highest point in the State, is located in the angle between the South Branch and the main river. The mean annual rainfall is about 42 inches.

The following table shows the principal cities and towns within the basin in this State:—

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Adams, ...	13,218	New Ashford, ...	92
Cheshire, ...	1,535	North Adams, ...	22,085
Clarksburg, ...	1,114	Williamstown, ...	3,961

Water Power.

The power situation on the Hoosac River is similar to that on the Housatonic River, inasmuch as the greater part of the water power of the stream is located outside of the State. In New York State there are several important powers on the Hoosac River, as shown by the following table which is taken from the water-power census of New York State made in 1908.¹

¹ Fourth Annual Report, New York State Water Supply Commission, p. 728.

Water Power on Hoosac River in New York.

LOCATION.	Product.	Available Fall (Feet).	Horsepower Capacity of Plant.
Schaghticoke, ...	Electric power, ...	180.0	20,000
Schaghticoke, ...	Flax, ...	7.5	150
Valley Falls, ...	Flax and cotton, ...	15.0	652
Valley Falls, ...	Cotton, ...	13.0	116
Valley Falls, ...	Feed, ...	14.0	295
Johnsonville, ...	Electric power, ...	34.5	5,000
Hoosick Falls, ...	Electric light, ...	19.5	600
Hoosick Falls, ...	Reapers, etc., ...	20.0	500

The water powers within Massachusetts were developed at an early date, and while most of them are small they have played an important part in the growth of manufacturing in this valley. The original manufacturing plants located in Adams, North Adams and Williamstown on account of the water power, but as the industries have grown their demand for power has greatly exceeded that available in the river, and steam auxiliaries of greater and greater size have been added, with the result that now the water power is distinctly the auxiliary, and the chief reliance is placed upon the steam plants. The water-power installations vary from 100 to 500 horsepower, and are used when there is water in the river. In some of the larger mills, such as the Berkshire Cotton Manufacturing Company at Adams, and the Arnold Print Works at North Adams, the demand for power and water for manufacturing purposes has become so great that the power is all furnished by steam, and no water power is at present developed at their privileges.

The total installed wheel capacity on the river, in Massachusetts, as shown by Table No. XXV., on page 167 and 168, amounts to 4,018 horsepower. There are a few small privileges that were formerly used that are now idle, but outside of these abandoned privileges there is no undeveloped water power on the river in this State.

Storage.

There are two reservoirs in the upper part of the basin that are drawn on for storage, one on each of the two branches. The Clarksburg Reservoir, on the North Branch, is owned by the Windsor Print Works, and according to the Geological Survey map covers an area of 49 acres. It can be drawn 8 feet with an estimated storage of 11,000,000 cubic feet. A large ice house of the Clarksburg Ice Company is located on its shores. The reservoir is formed by a low earth dam about 200 feet long, and to raise it materially would require a very long dam.

The Cheshire Reservoir is at the head of the South Branch, and has an area of 387 acres, formed by an earth dam about 1,000 feet long. It can be drawn to a depth of 8 feet giving an estimated storage of 67,000,000 cubic feet. This reservoir was originally built and formerly maintained by all the mills on the river, but those lower down have gradually dropped out, and at present it is maintained by the mills on the North Branch only.

The topography of the Hoosac Basin in this State is not such as to make the creation of additional storage for water power feasible.

TABLE XXV. — *Water Power on the Hoosac River in Massachusetts.*

[S. indicates steam; E., electricity.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-foot Per Square Mile, 80 Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
<i>Hoosac River.</i>										
1	Greylock Mills "B," . . .	Williamstown, .	Cotton goods, .	9	176	18	495	1.72	500 S.	-
2	Barber Leather Company, .	Blackinton, .	Leather, . . .	9	127	13	400	2.06	E.	-
3	Greylock Mills "A," . . .	Greylock, . . .	Cotton goods, .	9	124	17	400	2.09	1,200 S.	-
4	North Adams Manufacturing Company.	North Adams, .	Woolens, . . .	9	118	20	275	1.28	150 S.	-
<i>North Branch.</i>										
5	Windsor Print Works, . . .	North Adams, .	Textiles, . . .	9	40	18	150	2.30	-	Water power used for pumping only.
6	The Hoosac Cotton Mills, .	North Adams, .	Cotton goods, .	9	40	45	615	3.76	S.	No water power used.
7	Beaver Mill, ...	North Adams, .	-	9	39	30	320	3.04	E.	-
8	Strong, Hewat & Co., . . .	Briggsville, . .	Woolens, . . .	9	33	26	229	2.94	S.	-
9		Briggsville, . .	Sawmill, . . .	-	33	18	35	.65	-	Runs only part time.

TABLE XXV. — *Water Power on the Hoosac River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-foot per Square Mile %	Auxiliary Horsepower.	Remarks.
10	<i>South Branch.</i> Berkshire Hosiery Company,	North Adams,	-	-	74	16	-	-	-	Mill closed down.
11	Arnold Print Works,	North Adams,	Textiles,	9	74	10	-	-	-	No water power used.
12	Berkshire Hills Paper Company,	Zylonite,	Paper,	24	64	13	80	.76	-	-
13	Berkshire Hills Paper Company,	Zylonite,	Paper,	24	64	16	120	1.29	350 S.	-
14	Renfrew Manufacturing Company, Mill No. 2,	Renfrew,	Cotton goods,	9	62	18	150	1.48	-	-
15	Renfrew Manufacturing Company, Mill No. 1,	Renfrew,	Cotton goods,	9	60	18	134	1.36	-	-
16	Berkshire Cotton Manufacturing Company,	Adams,	Cotton goods,	9	52	-	-	-	-	No water power used.
17	L. L. Brown Paper Company,	Adams,	Paper,	24	50	12	40	.73	375 S.	-
18	L. L. Brown Paper Company,	Adams,	Paper,	24	46	10	40	.95	325 S.	-
19	W. C. Plunkett & Sons,	Adams,	Cotton goods,	9	46	19	180	2.26	350 S.	-
20	Renfrew Manufacturing Company, Mill No. 6,	Maple Grove,	Cotton goods,	9	46	14	125	2.13	125 S.	-
21	Adams Brothers Manufacturing Company,	Maple Grove,	Cotton goods,	9	37	15	120	2.33	-	-
22	Adams Woolen Mills, Inc.,	Maple Grove,	Woolens,	9	36	18	75	1.37	E.	-
23	H. C. Bowen & Son,	Cheshire,	Grist mill,	-	28	7	35	1.96	-	-
Total.					-	-	4,018	-	-	-

QUINEBAUG RIVER.

This stream, the most important tributary to the Shetucket River, rises in the towns of Brimfield, Wales and Holland, in Massachusetts, flows easterly and southerly through the towns of Southbridge and West Dudley, and after crossing the Massachusetts-Connecticut line joins with the French River and continues on a southerly course to join the Shetucket River, later finding its way into the Thames and Long Island Sound.

Its total length from Mill Brook in Brimfield to its mouth is about 60 miles, and its total drainage area is 725 square miles; but as most of this area, together with many of the larger and more important mill privileges, is in the State of Connecticut, this report is concerned only with 163 square miles of the upper drainage basin north of the Massachusetts-Connecticut line. This upper basin is about 12 miles north and south by 15 miles east and west, having an average rainfall of about 44 inches. With its 21 ponds and reservoirs, mostly of more than 25 acres each, it has a fairly steady run-off, with a total fall of about 250 feet between East Brimfield and the Connecticut line, where there are 14 water powers (given in the table), some of which are of considerable size and importance.

The following list shows the towns in Massachusetts that are largely or partly drained by the Quinebaug River: —

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Brimfield, ...	934	Southbridge, ...	14,217
Charlton, ...	2,213	Sturbridge, ...	1,618
Holland, ...	159	Wales, ...	337

It also takes in a small area in the southerly part of Warren and Brookfield on the north, and parts of Union and Woodstock, Conn., on the south.

Water Power.

The water power is well developed, and the mills as a whole seem to be making good use of the flow. Table No. XXVI, on pages 173 and 174, shows the details as to the various companies, with heads, horsepowers, etc. Several of the mills purchase auxiliary electric power from the Webster Gas and Electric Light Company, which has a transmission line through this district. Most of the mills are above 200 horsepower, the larger ones being located at Southbridge, namely, the Southbridge Printing Company, the American Optical Company, the Central Mills Company, and the Hamilton Woolen Company, which is the largest mill on the upper river.

The American Optical Company has a well-equipped factory for the production of lenses and optical goods, and formerly took power from a dam above the mill near the tail-race of the Central Mills Company, which was conveyed through a long canal under private dwellings to their mill. During recent years they have relinquished this privilege to the Central Mills Company and filled in the canal, and are now taking their power from the dam below, which was formerly owned by the Columbia Mills. They have built a new power station and mill buildings on this location, using about half of their installed wheel capacity on an average daily load of 1,250 K. W.

The Central Mills Company is soon to rebuild the dam below their privilege formerly owned by the American Optical Company, and will add this privilege to their present power, which will give them about 150 horsepower additional.

The Hamilton Woolen Company has two dams, one above and one at their lower new mills, with a mill pond between them at the mouth of Globe Brook, which admits of the use of three principal heads of 14, 16 and 22 feet, slightly modified by the wheel location with reference to the penstock, giving the five different heads shown in the table, and a total capacity of 1,636 horsepower.

The new mill of the Fiskdale Finishing Company is using power from the upper dam at Fiskdale, and is producing about the same line of goods as the Southbridge Printing Company. The lower mill is idle at present, but is capable of 300 horsepower.

The Litchfield Shuttle Company, about $1\frac{1}{2}$ miles above the Hamilton Mills at Globe Village, although using a little under 100 horsepower, is said to be the largest shuttle factory in the United States. There is a small box factory 1 mile above, using power intermittently and not given in the table.

Undeveloped Water Power.

A small undeveloped head exists below the E. S. Stevens Company, and is owned by them, which is not considered worth developing on account of the shallow flow of the meadows. Another undeveloped head above this company's mill, in which the Stevens Company owns an interest, cannot be developed to advantage. A small privilege of about 10 feet head is located about 1 mile above the Bermus Paper Company, and is owned by Wells & Beck. The Central Mills Company has a $7\frac{1}{2}$ -foot head on which about 150 horsepower is utilized that was recently bought of the American Optical Company. The Hamilton Woolen Company has an undeveloped privilege of 13 feet head just below their lower mill, which will develop about 300 horsepower. They also own a privilege at Westville Village, having a head of 30 feet and capable of producing about 600 horsepower, with a drainage area of 92 square miles.

The head at East Brimfield could be raised, but outside of the sites mentioned there seems to be no good opportunity for further development of power.

Storage.

Table No. XXVII., on page 175, gives the principal lakes and ponds on the Quinebaug watershed within this State, with data regarding their use for storage purposes.

The Hamilton Woolen Company is the principal owner of storage controlling Mashapoag Pond in Union, Conn., drawing from it into Hamilton Reservoir in Holland, which is of nearly equal capacity and is regulated at the outlet. The same company also owns and controls the flow from Walker and Cedar ponds. Altogether, this storage varies from 150,000,000 to 200,000,000 cubic feet in the upper 4 to 6 feet of draft.

The Fiskdale Finishing Company owns and controls Long Pond and Alum Pond, getting the benefit of the drainage area

of two smaller ponds above, but not controlling them. These produce over 87,000,000 cubic feet of storage which is usually drawn upon during the latter part of the week, when the Hamilton Woolen Company has shut off its supply from the Holland Reservoir.

No more sites of additional storage have been discovered in this basin. These storage reservoirs and several other ponds distributed through the upper basin tend to regulate the freshet flows from the drainage area, and to prevent disastrous effects from floods.

Altogether, the Quinebaug basin furnishes a steady flow for the greater part of the year, and the mills seem to be making an efficient use of it. A small part of the drainage area of Hatchet Brook, of a trifle less than 3 square miles, has been developed for water-supply purposes by the construction of four small reservoirs of 5, 3½, 22 and 67 acres, respectively, all within the town of Southbridge.

TABLE XXVI. — *Water Power on the Quinebaug River in Massachusetts.*

[S. indicates steam; E., electricity.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet Per Square Mile, 80 Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
1	E. S. Stevens Company, . . .	Quinebaug, . . .	Cotton goods, satins, etc.	9	153.0	12.00	180	.78	180 S.	-
2	Burnus Paper Company, . . .	West Dudley, . . .	Paper, . . .	24	147.0	12.00	220	1.37	E.	-
3	Southbridge Printing Company, . . .	Saundersdale, . . .	Bleaching, dyeing and finishing cottons.	9	185.0	10.00	200	1.62	E.	-
4	American Optical Company, . . .	Southbridge, . . .	Optical goods, . . .	9	126.0	11.50	400	3.30	E.	-
5	Central Mills Company, . . .	Globe Village, . . .	- . . .	-	107.0	7.50	-	-	-	Not yet utilized.
6	Central Mills Company, . . .	Southbridge, . . .	Cotton goods, thread and yarn.	9	108.0	20.00	564	2.87	E.	-
					106.0	17.75	514	3.04		
7	Hamilton Woolen Company, . . .	Southbridge, . . .	{ Cotton warp and worsted dress goods.	9	106.0	22.00	548	2.50		
8	Hamilton Woolen Company, . . .	Southbridge, . . .			96.0	16.00	38	.27	3,500 S.	-
					96.0	17.50	231	1.50		
					96.0	14.00	302	2.42		

TABLE XXVI. — *Water Power on the Quinebaug River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
9	Litchfield Shuttle Company, .	Southbridge, .	Foundry products and shuttles.	9	97.0	6.00	100	1.90	100 S.	-
10	Hamilton Woolen Company, .	Fiskdale and Sturbridge.	-	-	92.0	30.00	-	-	-	Undeveloped.
11	Snell Manufacturing Company, .	Fiskdale and Sturbridge.	Augers and bits, .	9	67.0	10.00	110	1.81	-	-
12	Fiskdale Finishing Company, .	Fiskdale and Sturbridge.	Bleaching, dyeing and finishing cottons	9	66.5	14.00	300	3.54	150 S.	Not running at present.
13	Fiskdale Finishing Company, .	Fiskdale and Sturbridge.	Bleaching, dyeing and finishing cottons.	9	66.0	21.00	500	3.97	350 S.	-
14	Snell Manufacturing Company, .	East Brimfield, .	Augers and bits, .	9	55.0	8.00	50	1.25	S.	-
	Total, ...	- - - - -	- - - - -	-	-	-	4,210	-	-	-

TABLE XXVII. — *Principal Lakes and Ponds on the Quinebaug River in Massachusetts.*

[Except where otherwise noted, areas are obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage (Million Cubic Feet).	Remarks.
1	Blood Pond, ...	Charlton and Dudley,	—	.34	80	—	—	—
2	Hicks Pond, ...	Charlton, ...	—	2.70	83	—	—	—
3	Hatchet Pond, ...	Woodstock, Conn.,	—	.50	30	—	—	—
4	Breakneck Pond, ...	Union, Conn., . . .	—	1.10	27	—	—	—
5	Hobbs Brook Pond, ...	Sturbridge, ...	—	5.00	30	—	—	—
6	Walker Pond, ...	Sturbridge, ...	Hamilton Woolen Com- pany.	3.20	100	4	17.4	—
7	Cedar Pond, ...	Sturbridge, ...	Hamilton Woolen Com- pany.	3.10	190	4	33.1	—
8	Pond north of Cedar, ...	Sturbridge, ...	—	.90	33	—	—	—
9	Long Pond, ...	Sturbridge, ...	Fiakdale Finishing Com- pany.	10.00	219	6	57.2	—
10	Alum Pond, ...	Sturbridge, ...	Fiakdale Finishing Com- pany.	1.00	172	4	30.0	—
11	Holland Pond, ...	Holland, ...	—	25.20	68	—	—	—
12	Hamilton Reservoir, ...	Holland, ...	Hamilton Woolen Com- pany.	21.75	300	4	52.2	—
13	Mashapaog Pond, ...	Union, Conn., . . .	Hamilton Woolen Com- pany.	7.70	286	4	48.6	—
14	Lead Mine Pond, ...	Sturbridge, ...	—	.90	68	—	—	—
15	Wales Pond, ...	Wales, ...	—	1.44	77	—	—	—
16	Little Alum Pond, ...	Brimfield, ...	—	.70	60	—	—	—
17	Great Pond, ...	Brimfield, ...	—	5.30	60	—	—	—
18	Two ponds near Charlton City, ...	Charlton, ...	—	2.90	39	—	—	—
19	Hatchet Brook Reservoir No. 3, ...	Southbridge, ...	—	3.03	23	—	—	Water supply.
20	Hatchet Brook Reservoir No. 4, ...	Southbridge, ...	—	2.80	67	—	—	—

FRENCH RIVER.

The watershed of the French River adjoins that of the Blackstone on the west. The river has its source in Spencer and Leicester, and flows in a southerly direction some 25 to 30 miles to the town of Thompson, Conn., where it enters the Quinebaug River of which it is the most important tributary.

The watershed of the French River comprises an area of 112 square miles. Its width varies from 3 to 7 miles, with an average of about 5 miles.

The general character of the basin closely resembles that of the Blackstone River, although it contains no large cities such as Worcester. The following list gives the towns within the basin in this State:—

NAME.	Population in 1915.
Dudley, ...	4,373
Leicester, ...	3,322
Oxford, ...	3,476
Webster, ...	12,565

Most of these towns originally grew up about water-power developments, as in the case of the Blackstone River.

Water Power.

Table No. XXVIII., on pages 178 and 179, gives the details regarding the developed water power on the French River. The water power on the French River, within this State, has been largely developed, and is almost all in use at the present time. The fall in the river above the Connecticut line is mostly grouped in two localities, the first being just above the State line, where the river forms the boundary line between Dudley and Webster. In this locality there are four privileges with an aggregate head of 48 feet. Above this there is a flat stretch of river extending from North Village, in Webster, up as far as the lower part of North Oxford. Between these two points there is but one privilege, that of A. Howarth & Son at Oxford.

The slope of the river becomes steep in North Oxford, and from there up to the Clark Woolen Company's privilege, at the foot of Greenville Reservoir in Rochdale, there are a succession of privileges developing a total of 182.5 feet of head. The only privilege unused at the present time is the lower one belonging to the Reid Mills in North Oxford.

The watershed of the French River is not large and its basin is narrow; its tributary basins are also short and small in area. However, there are water-power developments on Mill Brook at the outlet of Lake Chaubunagungamaug, on the outlet of Merino Pond in Dudley, and also on Mill Brook and Little River which enter at Oxford.

Storage.

Table No. XXIX., on page 180, shows the principal lakes and ponds on the watershed of the French River in this State. All but three are used either as mill ponds or as storage reservoirs, with a total estimated storage capacity of 1,000,000,000 cubic feet. Those used primarily as storage reservoirs control 50 square miles of drainage area, which is about 45 per cent. of the total watershed of the river.

These reservoirs have been developed in part by individual mills and in part by co-operation of a number of mill owners. S. Slater & Sons of Webster have played a leading part in the development and maintenance of these reservoirs.

The consensus of opinion appears to be that storage for water power has been developed about as much as is feasible, and that any additional reservoirs would be too costly. A reconnaissance of the basin substantiates this opinion, as all of the best sites have been developed and are in use.

TABLE XXVIII. — *Water Power on the French River in Massachusetts.*

[S. indicates steam; E., electricity.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Auxiliary Horsepower.
1	Dudley Woolen Mills,	Perryville,	Woolens,	9	98.3	9.0	125	1.53	S.
2	American Woolen Company,	Webster,	Woolens,	9	91.0	10.0	186	2.25	-
3	S. Slater & Sons,	Webster,	Woolens,	9	85.3	17.0	225	2.46	E.
4	S. Slater & Sons,	Webster,	Woolens,	9	85.0	12.0	425	4.56	S. and E.
5	A. Howarth & Son,	Oxford,	Woolens,	9	30.6	14.0	84	2.16	None
6	Reid Mills,	North Oxford,	Cotton goods,	9	24.5	14.0	65	2.06	None
7	Reid Mills,	North Oxford,	Cotton goods,	9	24.5	16.0	76	2.14	None
8	The Edwin Bartlett Company,	North Oxford,	Cotton goods,	9	24.2	15.0	248	3.44	S. and E.
9	The Edwin Bartlett Company,	North Oxford,	Cotton goods,	9	23.8	18.0			S. and E.
10	Thayer Woolen Company,	North Oxford,	Woolens,	9	22.2	22.0	175	3.95	S.
11	D. N. Taft,	North Oxford,	Woolens,	9	22.1	14.5	85	2.93	None
12	Thayer Woolen Company,	North Oxford,	Woolens,	9	21.8	21.0	175	4.20	S.

	Comins & Co.,	Rochdale,	Woolens,	9	20.1	15.0	140	5.12	S.
13	Rochdale Mills, American Woolen Company,	Rochdale,	Woolens,	9	19.5	16.0	174	6.14	-
14	E. G. Carleton & Sons,	Rochdale,	Woolens,	9	18.6	12.0	56	2.85	S.
15	A. Hankey & Son,	Rochdale,	Machine shop,	9	15.2	19.0	118	4.48	S.
16	J. D. Clark Woolen Company,	Rochdale,	Woolens,	9	14.3	11.0			
17	J. D. Clark Woolen Company,	Rochdale,	Woolens,	9	14.3	17.0	188	3.28	S.
18	J. D. Clark Woolen Company,	Rochdale,	Woolens,	9	14.3	14.0			
19	J. D. Clark Woolen Company,	Rochdale,	Woolens,	9	3.2	17.0	35	3.53	S. and E.
20	R. & C. Ashworth,	Leicester,	Woolens,	9	9.9	11.0	100	12.40	E.
21	Mill Brook (Lake Chautauque, N. Y.), S. Slater & Sons,	Webster,	Woolens,	9	5.0	55.0	153	6.13	S.
22	Merino Pond Brook, Stevens Linen Works,	Dudley,	Linen goods,	9	5.0	13.0	40	6.78	S.
23	Stevens Linen Works,	Dudley,	Linen goods,	9	8.5	16.0	50	4.06	S.
24	Mill Brook (Oxford), D. N. Taft (Berman Mill),	Oxford,	Woolens,	9	28.4	8.0	35	1.69	None
25	E. S. Dimock, Little River,	Buffamville,	Shoddy,	9	27.6	16.0	110	2.74	E.
26	Dodge Felting Company,	Buffamville,	Felt goods,	9	-	-	3,168	-	-
	Total,	-	-	-	-	-	-	-	-

TABLE XXIX. — *Principal Lakes and Ponds on the French River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1:80,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drainage Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Estimated Storage Pond (Million Cubic Feet).	Remarks.
1	Lake Chaubunagungamaug.	Webster,	S. Slater & Sons,	9.9	1,188 ¹	4	207.0	-
2	Mill Pond,	Dudley,	Stevens Linen Works,	-	20 ¹	2	2.0	-
	Merino Pond,	Dudley,	Stevens Linen Works,	4.9	83	4	22.0	-
3	Peter Pond,	Dudley,	Stevens Linen Works,	.7	44 ¹	4	6.0	-
4	Larned Pond,	Dudley,	Stevens Linen Works,	3.1	100 ¹	15	17.5	-
5	Hayden Pond,	Dudley,	Stevens Linen Works,	1.8	93 ¹	17	32.5	-
6	Pierpont Meadow Pond,	Dudley and Charlton,	Association of mills,	1.5	100	10	27.0	-
7	Gore Pond,	Dudley and Charlton,	-	2.2	222	-	-	Formerly used for storage. Draft of 6 or 6 feet.
8	South Charlton Reservoir,	Charlton,	Association of mills,	8.3	240 ¹	15	137.0	-
9	Slaters Reservoir,	Charlton,	S. Slater & Sons,	13.6	125 ¹	16 ¹	90.0	-
10	Robinsons Pond,	Oxford,	D. N. Taft,	1.6	100	7	22.0	-
11	Saccarappa Reservoir,	Oxford,	S. Slater & Sons,	2.6	125 ¹	22	120.0	-
12	Stiles Reservoir,	Leicester and Spencer,	Stiles Reservoir Company,	4.0	401	23	201.0	-
13	Cedar Meadow Pond,	Leicester,	Rochdale Mills,	3.8	158	5	32.0	-
14	Burncoat Pond,	Leicester and Spencer,	Rochdale Mills,	2.9	152	10	44.0	-
15	Sargents Pond,	Leicester,	-	3.1	84	-	-	-
16	Greenville Reservoir,	Leicester,	Clark Woolen Company,	14.3	44	-	-	Mill pond.
17	Henshaw Pond,	Leicester,	-	-	35	-	-	-

¹ Areas from large scale plan of colinbia local waterway

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	12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BLACKSTONE RIVER.

The Blackstone River is formed near the city of Worcester the union of several brooks, and flows in a southerly direction through Millbury, Uxbridge and Blackstone into Rhode Island where it passes through Woonsocket, Lonsdale and Pawtucket and enters the Providence River at Providence. It has a total drainage area of about 475 square miles, of which 103 square miles are in the State of Massachusetts.

The principal tributaries are as follows: —

NAME.	Drainage Area (Square Miles).
River, ...	34.5
Branch River, ...	103.5
Northford River, ...	58.0
Blackstone River, ...	34.9
Wigamond River, ...	37.9

Blackstone River enters the Blackstone below the dams in Woonsocket, although its watershed is almost entirely in Massachusetts. There are two privileges on it in Woonsocket, the upper which is partly in Massachusetts. The Branch River, on the other hand, drains an area largely in Rhode Island, although following in a northeasterly direction it crosses into this State, where it enters the main river between the privileges of the Cranston Mills of the American Woolen Company and the Blackstone Manufacturing Company.

The following towns in this State are largely drained by the Blackstone River: —

NAME.	Population in 1915.	NAME.	Population in 1915.
Blackstone, ...	5,689	Northbridge, ...	9,354
Douglas, ...	2,179	Shrewsbury, ...	2,794
Easton, ...	6,250	Sutton, ...	2,839
Hopkinton, ...	2,663	Upton, ...	2,036
Needham, ...	923	Uxbridge, ...	4,921
Millbury, ...	5,295	Worcester, ...	162,697

The cities of Providence, R. I., and Worcester, Mass., might be said to be situated at the mouth and the headwaters of the Blackstone River, respectively, the intervening territory being well covered with small manufacturing towns in which the manufacture of textiles predominates. The phenomenal growth of Providence and Worcester has been due to their favorable situations as regards transportation, but the location of the other towns in the above list was probably determined by the water power of the Blackstone River. The early growth of this region was further aided by an attempt to develop water transportation by the construction of the Blackstone Canal from Providence to Worcester, which was completed in 1828, and although of advantage to the towns in the valley, it proved unprofitable for the promoters, and went out of use in 1838. About 1848 its place was taken by the Providence & Worcester Railroad, which acquired the property of the Canal Company along the river.

While the Blackstone watershed is far from level, yet the hills are rolling and the region is well suited to farming. Due no doubt to the many manufacturing communities, a considerable part of the watershed was cleared and devoted to agricultural purposes at one time. However, this valley also shared the general movement toward the abandonment of farm land that occurred throughout New England during the latter part of the nineteenth century, and large areas have grown up to brush and small trees; but a strong tendency in the opposite direction is now discernible.

Water Supply.

The only large city in the basin in this State is Worcester, and the chief problem of water supply has been concerned with that city. The waters of Lynde Brook were acquired in 1863, a part of Tatnuck Brook added in 1883, and the upper part of Kettle Brook in 1895. These watersheds comprise an area of 12.25 square miles in the Blackstone basin. To this has since been added Kendall Reservoir in the headwaters of the South Branch of the Nashua River, and Pine Hill Reservoir, also in the Nashua watershed, is now under construction. These two

add 9.35 square miles, making a total of 21.60 square miles. It is estimated that the system as thus enlarged will provide for a population of 300,000.

Water Power.

Information regarding the water power of the Blackstone River is condensed in Table No. XXX., on pages 186 to 189, and the accompanying profile of the river from the State line up to Worcester. The stream has long been noted as being one of the most completely utilized streams in the world, and justly so.

At one time that part of the river within this State was almost completely in use, including not only the main river but also all the important tributaries, and even those of but few square miles' drainage, such as Dorothy and Singletary brooks. It might almost be said that there were no undeveloped water-power privileges, and by far the greater part of this water power is still in use, although as in other parts of the State there has been a falling off in some of the smaller privileges.

The size of the mills is such that in most cases their demand for power is in excess of the capacity of the stream, so that either steam auxiliary plants or electricity are the main dependence of the mills. The watershed is traversed by the transmission lines of the Connecticut River Power Company, and, as will be seen from the table referred to above, electric power is largely used by the mills.

The elevation of the upper dam at the South Works of the American Steel and Wire Company in South Worcester is 438.5 feet above sea level. One hundred and fifty-one feet of the total fall occurs in Rhode Island below the American Woolen Company's privilege in Blackstone and Woonsocket, and all of this is developed. Between the American Steel and Wire Company's dam and the American Woolen Company's tail-water there is thus a total fall in the river of 287.5 feet. Within these limits there was at one time a total gross fall of about 260 feet developed and in use, although the total net effective head was perhaps 25 feet less. At six of the privileges with an aggregate gross fall of about 60 feet no water power

is developed at the present time. With the exception of the low head privilege formerly occupied by the Saunders Grist Mill these unused privileges are all at the upper end of the river above the National Crash Company's dam in Millbury.

Storage.

Table No. XXXI., on pages 190 and 191, gives the principal lakes and ponds on the Blackstone watershed within this State, with data regarding their use for storage purposes. This table shows a total of 1,326,000,000 cubic feet storage capacity, of which 334,000,000 cubic feet is a part of Worcester's water-supply system, while the remaining 992,000,000 cubic feet are stored for the benefit of water powers and for manufacturing purposes.

The first storage to be created on the river was for the benefit of the Blackstone Canal. Chapter 27 of the Acts of 1822, which incorporated the Blackstone Canal Company, gave it the right to raise and use Lake Quinsigamond, Dorothy Pond and North Pond in Worcester for storing water required by the canal. After the Canal Company went out of business it sold its rights in the ponds named below for the following sums:—

Dorothy Pond, ...	\$375 00
Lake Quinsigamond, ...	400 00
North Pond, ...	825 73
Ramshorn Pond, ...	500 00

Between 1820 and 1870 a number of natural ponds were raised and artificial reservoirs created by mills interested in a more uniform flow of the river. In most cases these were built by an association of the mills most directly affected, as represented by the Willis Pond Reservoir, Manchaug Pond on Mumford River, Singletary Pond on Singletary Brook, Clarks and Sibley Reservoirs on Cold Spring Brook, and reservoirs on Kettle Brook above Worcester. As far as could be learned, there have been no new reservoirs built within the last half century except those required for municipal water supplies, with the exception of North Pond on Mill Brook, in the towns of Hopkinton, Milford and Upton, where the dam was rebuilt

in 1902. This had been formerly used as a storage reservoir, but had fallen into disuse.

Concerning the question of building additional reservoirs on the watershed of the Blackstone River within this State it must be said that the cost at the present time would be prohibitive if built for water-power purposes alone. The best locations have already been developed, and those remaining are precluded from use either by the towns which have grown up or the valuable nature of the land which would be affected. There appears to be no danger of a shortage of the water required for manufacturing purposes on the river below Worcester, but in that city the requirement of additional storage is not an impossibility, for a large and extensive manufacturing district requiring a considerable supply of water has grown up about the stream. The largest mills are those of the American Steel and Wire Company, whose North Works are located on the outlet of North Pond, and Central Works and South Works on the main river. This company requires a large amount of water in its various plants, in all of which it uses extensive return systems, and has been active in the conservation and use of the existing storage on the river above its privileges.

TABLE XXX. — *Water Power on the Blackstone River in Massachusetts.*

(S. indicates steam; E., electricity; G., gas.)

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-foot per Square Mile 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
1	Saranac Mills, American Woolen Company.	Blackstone.	Woolens.	9	363.0	9.5	396	1.27	50	S.	-
2	Blackstone Manufacturing Company.	Blackstone.	Cotton goods.	9	260.0	31.0	1,500	2.05	68	S.	-
3	Lawrence Felting Company.	Millville.	Felt goods.	9	258.0	13.0	725	2.33	65	S.	-
4	Hecla Mills, American Woolen Company.	Uxbridge.	Woolens.	9	147.0	8.0	180	1.08	45	S.	-
5	Stanley Woolen Company.	Uxbridge.	Woolens.	9	146.0	11.5	220	1.51	115	S. and E.	-
6	Kupfer Brothers Company.	Riverdale.	Paper.	24	141.0	10.0	350	2.73	10	S.	-
7	Paul Whitin Manufacturing Company.	Northbridge.	Cotton goods.	9	139.0	10.0	325	2.57	98	S. and E.	-
8	S. Slater & Sons.	Farnumsville.	Woolens.	9	135.0	7.0	25	.29	10	E.	-
9	Fisher Manufacturing Company.	Fisherville.	Cotton goods.	9	124.0	10.5	389	3.04	120	S. and E.	-
10	Saunders Cotton Mills.	Saundersville.	Cotton goods.	9	93.0	11.5	275	2.33	10	S.	-
11	The Anco Mills.	Wilkinsonville.	Cotton goods.	9	86.0	21.0	800	3.08	6	E.	-
12	Worcester Consolidated Street Water Company.	Millbury.	Electricity.	24	83.0	13.5	-	-	-	-	Steam power station. No water power generated.
13	Cordia Mills.	Millbury.	Cotton goods.	9	77.0	14.0	172	1.77	10	E.	-

		Millbury,		Linen goods,	9	77.0	13.0	160	1.76		S.		
14	National Crash Manufacturing Company.	Millbury,	.	.	.	.	.	.	.	.	.	.	.
15	-	Millbury,	.	-	-	-	-	-	-	-	-	-	-
16	Felters Company, Keystone Mill.	Millbury,	.	Felt goods,	.	71.0	10.0	-	-	-	-	Formerly Atlanta Woolen Company, not in use.	-
17	Worcester Consolidated Street Railway Company.	Millbury,	.	-	-	68.0	-	-	-	-	-	Formerly 8-foot head. Dam washed out.	-
18	Stevens,	Worcester,	.	-	-	64.0	-	-	-	-	-	Formerly 10-foot head. Not in use.	-
19	American Steel and Wire Company, South Works.	Worcester,	.	Wire,	.	63.0	4.5	-	-	-	S.	Formerly 8-foot head. Not in use.	-
20	American Steel and Wire Company, South Works.	Worcester,	.	Wire,	.	63.0	7.5	-	-	-	S.	No water power generated.	-
21	American Steel and Wire Company, Central Works.	Worcester,	.	Wire,	.	49.5	4.0	-	-	-	S.	No water power generated.	-
22	M. J. Whittall,	Worcester,	.	Carpets,	.	49.3	8.0	80	2.24	23	-	-	-
23	Hopeville Manufacturing Company.	Worcester,	.	Woolens,	.	48.5	6.0	-	-	7	S.	No water power generated.	-
24	Worcester Electric Light Company.	Worcester,	.	Electricity,	.	48.3	12.0	-	-	50	S.	Steam power station; no water power used.	-
25	P. P. Downey,	Worcester,	.	Files,	.	31.5	10.0	-	-	161	-	-	-
26	Ettrick Mills,	Stoneville,	.	Carpets,	.	17.8	21.0	200	5.90	37	S.	-	-
27	<i>Remahorn Brook.</i> Pondville Woolen Company,	Pondville,	.	Woolens,	.	7.7	12.0	100	11.90	-	S.	-	-
28	A. D. Windle,	West Millbury,	.	Wool scouring,	.	3.5	15.0	18	3.77	-	E.	-	-
29	H. W. Glover,	West Millbury,	.	Sawmill,	.	3.5	8.0	16	3.93	-	E.	-	-
30	Ramahorn Mills,	West Millbury,	.	Woolens,	.	3.4	12.0	20	5.40	-	E.	-	-
31	<i>Mumford River.</i> Uxbridge Worsted Company,	Uxbridge,	.	Woolens,	.	57.5	13.0	100	1.47	-	E.	-	-
31a	Davis & Brown Woolen Company.	Uxbridge,	.	-	-	-	-	-	-	-	-	-	-
32	Uxbridge Cotton Mills,	North Uxbridge,	.	Cotton goods,	.	51.8	16.0	360	4.78	-	S.	-	-
33	Whitin Brothers (Linwood Mills)	Linwood,	.	Cotton goods,	.	51.5	12.0	225	4.01	-	S.	-	-
34	Whitinsville Cotton Mills,	Whitinsville,	.	Cotton goods,	.	49.6	18.0	292	3.60	-	E.	-	-

TABLE XXX. — *Water Power on the Blackstone River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet Per Square Mile 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
35	<i>Musford River</i> —Con. The Whitin Machine Works,	Whitinsville,	Machinery,	9	48.9	20.0	350	3.94	350	S.	-
35a	The Schuster Woolen Company.	East Douglas,	Woolens,	9	28.0	9.0	100	4.33	-	E.	Known as "Gilboa" privilege. Horsepower estimated.
35b	The Hayward Woolen Company.	East Douglas,	Woolens,	9	26.0	10.0	100	4.23	-	E.	Horsepower estimated.
36	Manchaug Company,	Manchaug,	Cotton goods,	9	20.8	84.0	850	5.75	-	S.	Three privileges.
37	Manchaug Company,	Manchaug,	Cotton goods,	9	20.8						
38	Manchaug Company,	Manchaug,	Cotton goods,	9	16.0						
39	<i>Quinsigamond River.</i> Washington Emery Mills,	North Grafton,	Emery,	9	25.9	18.0	150	3.54	-	S.	-
40	The Linnen Thread Company,	North Grafton,	Linen goods,	9	25.7	25.0	450	7.71	903	S.	-
41	<i>Singletary Brook.</i> Edward F. Rice & Co.,	Millbury,	Cotton goods,	9.5	5.2	19.0	55	6.24	-	E.	-
42	Mayo Woolen Company,	Millbury,	Woolens,	-	5.1	-	-	-	-	-	-
43	W. W. Windle,	Millbury,	Wool scouring,	9.5	5.0	19.0	55	6.37	-	E.	-
44	Mayo Woolen Company,	Millbury,	Woolens,	-	4.9	-	-	-	-	-	-

[illegible]

TABLE XXXI. — *Principal Lakes and Ponds on the Blackstone River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Ironstone Reservoir,	Uxbridge,	-	4.9	86	-	-	48 acres in Rhode Island; 38 acres in Massachusetts.
2	Nipmuck Pond,	Mendon,	-	.8	66	-	-	-
3	Bad Luck Pond,	Douglas,	-	1.0	67	3.5	10.0	Raised natural pond.
4	Willis Pond Reservoir,	Douglas,	Manchaug Reservoir Com- pany.	8.9	250	22.0	180.0	Artificial reservoir; dam, 800 feet long, 30 feet maximum height.
5	Manchaug Pond,	Douglas and Sutton,	-	6.7	360 ¹	15.0	191.0	Raised pond; dam, 19 feet maximum height.
6	Stevens Pond, west of Man- chaug Village.	Sutton,	Manchaug Reservoir Com- pany.	16.0 ²	75	-	-	Artificial mill pond.
7	Burt Pond,	Sutton and Northbridge,	-	3.6	26	-	-	-
8	Whitins Pond,	Uxbridge, Sutton and Northbridge.	Whitins Machine Works,	49.0	350	4.0	61.0	Artificial mill pond.
9	Pleasantdale Pond,	Sutton,	Providence Drapery Rod Company.	3.6	26	-	-	Artificial mill pond.
10	Clarks Reservoir,	Sutton,	Providence Drapery Rod Company.	2.6	40	16.0	14.0	Artificial reservoir; dam, 20 feet maximum height.
11	Sibley Reservoir,	Sutton,	Sibley Reservoir Company,	.5	53	12.0	20.0	Artificial reservoir; dam, 21 feet maximum height.
12	Singletary Pond,	Sutton and Millbury,	Mills on Singletary Brook,	4.2	256	7.0	103.0	Raised natural pond.
13	Pratt Pond,	Upton,	L. A. Snow,	2.1	23	6.0	4.0	-
14	Goddard Pond,	Grafton,	-	36.6	76	-	-	Mill pond. Mill not in operation.

NASHUA RIVER.

The Nashua River, the largest tributary of the Merrimack within this State, is formed at Lancaster by the union of its North and South branches, and runs in a direction somewhat east of north a distance of about 25 miles measured in a straight line to Nashua, N. H., where it enters the Merrimack River.

The total drainage area of the Nashua River is 530 square miles, of which about 262 square miles are contributed by the North and South branches. On the eastern side of the river the watershed divide is from 3 to 5 miles from the main river, and there are no large tributaries. On the opposite side below the junction of the branches the river is joined by Catacoona-mug Brook, with a watershed of 20.5 square miles; Squannacook River, with a watershed of 73 square miles; and the Nissitissit River, with a watershed of 58 square miles. The upper part of the basin is steep and rocky and largely covered with forests.

The principal cities and towns of the basin are located along the river and its tributaries, and in most cases grew up in the vicinity of water-power developments. Their population is shown by the following table:—

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Ashburnham, ...	2,059	Lancaster, ...	2,585
Ashby, ...	923	Leominster, ...	17,846
Ayer, ...	2,779	Lunenburg, ...	1,610
Boylston, ...	783	Pepperell, ...	2,539
Clinton, ...	13,192	Princeton, ...	800
Fitchburg, ...	39,656	Shirley, ...	2,351
Groton, ...	2,333	Sterling, ...	1,408
Harvard, ...	1,104	Townsend, ...	1,812
Holden, ...	2,514	Westminster, ...	1,394

The mean annual rainfall varies from 40 inches at the mouth to 46 inches at the headwaters, with an average of about 42 inches. The run-off of the South Branch is completely controlled by the Wachusett Reservoir of the metropolitan system at Clinton, and on the remainder of the watershed there are numerous natural and artificial ponds which prevent disastrous floods.

Water Power.

Two of the most important water powers on the river are located at Nashua, N. H. The lowest belongs to the Jackson Company, whose dam is located near the center of the city, with a canal from 1,400 to 1,500 feet long, which gives a head of 20 or 21 feet on which there were installed turbines having a total of 1,966 horsepower in 1899, at the time Prof. Dwight Porter made his reconnaissance of the Merrimack watershed. A mile and a half above this is a privilege occupied by the Nashua Manufacturing Company, where water wheels aggregating 3,400 horsepower were installed on a head of 36 feet obtained by a canal about 3 miles long, starting from what was known as the Mine Falls Dam. The pond above this extends nearly up to what was known as the Runnells Falls Dam, which was used solely for storage purposes, and with a head of about 6 feet it backs the water up over the Massachusetts-New Hampshire boundary line.

On that part of the river that is in the State of Massachusetts there are a considerable number of water-power privileges with a total installation of water wheels amounting to about 12,000 horsepower, as shown in detail by Table No. XXXII., on pages 198 to 201.

The largest installation on the South Branch of the river is that of the metropolitan system at the Wachusett dam in Clinton, where four wheels of 1,200 horsepower each, making a total of 4,800 horsepower, are installed. On the main river, below the junction of the North and South branches, there are three privileges developing 37 feet of the 56 feet or so of fall between the junction and the State line.

The North Branch is rather fully developed, there being 22 privileges between its mouth and the Crocker Burbank Com-

pany's mill No. 7 below the Wachusett station above Fitchburg. Seventeen of these are located in Fitchburg, where the river has a total drop of 236 feet and one privilege succeeds another, the pond of one forming the tail-water of the privilege above. Below Fitchburg on the North Branch there are five privileges developing 60 feet in the total of 119 feet fall. Part of the remaining 49 feet could be developed, but it is so distributed as not to constitute any single large privilege.

Some of the smaller tributaries were also rather fully developed during the nineteenth century, and many of the privileges on Monoosnoc Brook in Leominster, and on Catacoonamug Brook in Shirley, are still in use. The Squannacook and Nis-sitissit rivers have but slight fall, the greater part of which is in use.

A great many of the smaller water-power privileges near the headwaters of the river have been abandoned, and while there are a number of these, and some that have never been in use, there are no important stretches that are undeveloped on this watershed.

Storage.

The principal storage reservoir of the basin is the Wachusett Reservoir above Clinton. This was built by the Metropolitan Water and Sewerage Board in 1900-05, at a cost of about \$11,000,000. The drainage area was formerly 118 square miles, 10 of which have been acquired and are being developed by the city of Worcester, thus diverting the water to the watershed of the Blackstone. The dam at Clinton was built across a narrow gorge, the flow line of the reservoir being 129 feet above the original river bed, and the lowest point of the foundation extending 79 feet below the same point. The main dam is built of masonry, and, including terminal structures, is 971 feet long, with an additional 452 feet of waste weir adjoining it.¹ The reservoir has an area of 6½ square miles, forming the largest body of fresh water in Massachusetts. It extends upstream for nearly 8½ miles, and overflows land formerly occupied by about 1,700 inhabitants and by a number of churches and schools. The reservoir has a capacity of 64,968,000,000

¹ Fifth annual report, Metropolitan Water and Sewerage Board (1906, p. 87).

gallons, or 8,680,000,000 cubic feet, sufficient to completely control the run-off above. Directly below the reservoir are the Lancaster Mills, who formerly had two water powers with heads of 6 and 28 feet, respectively, which were destroyed by the appropriation of this branch of the river by the metropolitan district; but by the provisions of the metropolitan water act not less than 12,000,000 gallons per week of compensation water must be allowed to flow past the main dam, together with such an additional amount not exceeding the above as the Lancaster Mills shall require for domestic or manufacturing purposes other than the production of water power.

In addition to the metropolitan supply, which is carried outside the Nashua drainage basin, the city of Fitchburg and the villages of Clinton, Leominster, Lancaster, Shirley, Ayer, Pepperell, Ashburnham, Groton and Holden all have public water supplies within the basin, and the city of Fitchburg has acquired the privilege of taking Stodge Meadow Pond and Ward Pond at the upper end of the Souhegan River. In connection with the water-supply system of Fitchburg, there are six reservoirs with a total storage of over 225,000,000 cubic feet.

There are also seven reservoirs in the basin that were raised or entirely created for the benefit of the various mills. In most cases these were paid for by an association of the mills located on the tributaries or that portion of the main river directly below the reservoirs. The details are shown in Table No. XXXIII. of lakes and ponds of the Nashua River watershed, on pages 202 and 203.

It is proposed to build another reservoir on Whitman Brook a mile or so above the Westminster station, in addition to the one below South Ashburnham which was built about 1909.

Additional storage on the Nashua River could be used on a total fall of about 65 feet at Lawrence and Lowell on the Merrimack River, and on 56 feet on the Nashua River at Nashua, N. H. On the main river below Lancaster there is an additional head of 37 feet in use in this State, while varying amounts of fall have been developed on the tributaries. As to the North Branch of the river, the upper part of the basin is so mountainous and the valleys so steep and narrow that any

great increase in the present storage is hardly feasible. Doubtless small reservoirs can be built which might be of considerable value for manufacturing purposes, but the topography of the watershed above Fitchburg is such as to preclude the practicability of building large reservoirs for storing water primarily for water power.

If we disregard the element of cost it is physically possible to create storage on Mulpus Brook and on the Squannacook and Nissitissit rivers. The slope of the two rivers is not very great, and by building a high dam near the mouth of each river reservoirs of large capacity could be created. The topographical map shows that on Squannacook River a dam 80 feet high and about half a mile long would flow an area of 6.5 square miles, giving a storage capacity of 4,000,000,000 cubic feet, as indicated by the map, and flooding Townsend Harbor and the greater part of the village of Townsend, as well as the Peterboro and Shirley branch of the Boston & Maine Railroad for a distance of about 7 miles. A definite survey might show that a lower dam could be built which would eliminate a considerable part of the damage caused in Townsend and Townsend Harbor by a dam of the greater height, and still leave a reservoir of considerable area and capacity. The drainage area would be about 70 square miles. Outside of the villages the region which would form the bed of the proposed reservoir is timber land of no great value.

On the Nissitissit River a dam could be built a quarter of a mile above North Village, at which point the tributary drainage area amounts to 55 square miles. If a similar dam were built here about 80 feet high and half a mile long it would create a reservoir of 5.6 square miles, according to the topographical map, extending up as far as West Hollis and Brookline. The storage would amount to about 2,600,000,000 cubic feet. The Milford Branch of the Boston & Maine Railroad, a single track line, runs up through this valley, and would require re-locating, but outside of this the damage would not be excessive. The greater part of the valley is timber land.

Whenever a complete study of the Merrimack River storage is made both sites should be considered and might be de-

veloped, especially if the Merrimack River is canalized as far as Lowell and it becomes necessary to construct reservoirs to compensate the mills for the water required for lockage by the canal. The head on which water stored in these two reservoirs could be used amounts to 178 feet in the case of the Squannacook, and about 125 feet for the Nissitissit, which is not enough for a profitable venture at the present time, as it is doubtful if the value of the stored water would justify the expenditure.

The site on the Nissitissit River, the upper end of which is in New Hampshire, appears to be the more favorable of the two, but in view of the great cost of these reservoirs it was not considered that a detailed survey of the sites was warranted at the present time.

TABLE XXXII. — *Water Power on the Nashua River in Massachusetts.*

[S. indicates steam; E., electricity.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
<i>Nashua River.</i>											
1	Nashua River Paper Company.	East Pepperell.	Paper.	24	433	20.0	500 ¹	.64	87	-	Head developed at two dams of 16 and 5.7 feet.
2	Nashua River Paper Company.	Groton.	Paper.	24	427	7.0	250 ¹	.92	139	-	-
3	Fitchburg & Leominster Street Railway Company.	Lancaster, Harvard and Shirley.	Electricity.	22	302	9.0	315	1.27	128	8	-
4	South Branch Commonwealth of Massachusetts.	Clinton.	Electricity.	24	109	90.0	4,800	5.33	4,135	-	Electricity sold to Connecticut River Transmission Company.
<i>North Branch.</i>											
5	Ponikin Mills.	Lancaster.	Cotton goods.	9	125	12.0	175	1.28	-	8.	-
6	Worcester Consolidated.	Leominster.	Electricity.	24	107	19.0	438 ¹	2.36	110	8.	-
7	E. A. Whitney Carriage Company.	North Leominster.	-	-	85	9.0	155 ¹	2.23	-	-	-
8	Wheelwright Paper Company.	North Leominster.	Paper.	24	84	10.0	136	1.77	12	8.	-
9	Merriam, Hall & Co..	North Leominster.	Furniture.	9	83	9.0	100	1.47	6	8.	-

No.	Company.	Fitchburg.	Paper.	24	65	14.0	150	1.81	6	S. and E.
10	Falulah Paper Company,	Fitchburg.	Paper,	24	65	14.0	150	1.81	6	S. and E.
11	Fitchburg Duck Mills,	Fitchburg.	Cotton goods,	9	65	17.0	235	2.34	5	250 S.
12	Arden Mills (American Woolen Company),	Fitchburg.	Woolens,	9	64	14.0	142	1.74	3	-
13	Wheeler Paper Company,	Fitchburg.	Paper,	24	64	19.0	221	2.00	13	S.
14	Union Machine Company,	Fitchburg.	Machine shop,	10	63	9.0	100	1.94	3	E.
15	J. Cushing & Co.,	Fitchburg.	Grain and flour,	10	63	11.0	75	1.19	4	E.
16	Putnam Machine Company,	Fitchburg.	Machine shop,	10	62	10.0	-	-	-	Water power not in use.
17	Parkhill Manufacturing Company, Mill B.	Fitchburg.	Cotton goods,	9	62	9.0	95	1.87	7	-
18	Star Worsted Company (Pitts),	Fitchburg.	Woolens,	9	62	11.0	116	1.87	6	S.
19	Star Worsted Company,	Fitchburg.	Woolens,	9	60	11.0	116	1.93	5	S.
20	Grant Yarn Company,	Fitchburg.	Cotton goods,	9	60	10.0	100	1.83	9	E.
21	F. F. Woodward & Co.,	Fitchburg.	Grain and flour,	-	59	8.0	-	-	-	Not in use in 1916.
22	Fitchburg Paper Company,	Fitchburg.	Paper,	24	58	16.0	155	1.84	9	S. and E.
23	Fitchburg Paper Company,	Fitchburg.	Paper,	24	58	11.0	98	1.69	4	S. and E.
24	Crocker, Burbank Company, No. 4.	Fitchburg.	Paper,	24	41	16.0	150	2.53	5	S. and E.
25	Crocker, Burbank Company, No. 6.	Fitchburg.	Paper,	24	41	21.0	220	2.82	4	S. and E.
26	Crocker, Burbank Company, No. 7.	Fitchburg.	Paper,	24	40	24.0	250	2.87	11	S. and E.
27	Crocker, Burbank Company, No. 1.	Fitchburg.	Paper,	24	12	140.0	325	2.13	-	S. and E.
	North Branch (Whitman River).									Static head, 140 feet; effective head estimated.
28	Crocker, Burbank Company, No. 2.	Fitchburg.	Paper,	24	28	45.0	300	2.46	-	S. and E.
29	Crocker, Burbank Company, No. 3.	Fitchburg.	Paper,	24	28	24.0	212	2.48	38	S. and E.
										Two privileges of 24 feet each.

Power estimated.

TABLE XXXII. — *Water Power on the Nashua River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Area of Pond (Acres).	Auxiliary Horsepower.	Remarks.
30	<i>North Branch (Nookages River),</i> Booli Mills (American Woolen Company).	Fitchburg.	Woolens.	9	17	10.0	-	-	-	-	Water power not used.
31	Cornforth & Marx.	Fitchburg.	-	-	17	-	-	-	-	-	Not in operation.
32	Crocker, Burbank Company, No. 5.	Fitchburg.	Paper.	24	16	24.0	175	5.02	-	S. and E.	-
33	<i>North Branch (Monoenooc Brook),</i> "Handfold" Toilet Paper Company.	Leominster.	Paper.	9	11	15.0	60	4.00	-	S.	-
34	E. A. Whitney Carriage Company.	Leominster.	-	-	11	-	-	-	-	-	-
35	Tilton & Cook Company.	Leominster.	-	-	11	-	-	-	-	-	-
36	Jewett Piano Company.	Leominster.	Fianos.	9	11	10.0	30	2.00	-	S.	-
37	B. F. Blodgett & Co.,	Leominster.	Combs.	10	10	4.5	12	2.93	-	-	-
	The Damon Company.	Leominster.	Celluloid goods.	9	-	8.0	15	2.06	-	S.	-

38	Rockwell Woolen Company. . .	Leominster, . .	Woolen yarns, . .	9	10	16.0	100	6.88	-	S.	-	-
39	F. C. Smith, ...	Leominster, . .	Piano cases, . .	9	7	18.0	101	8.82	-	S.	-	-
40	Fitchburg Gas and Electric Light Company. <i>Cateconawug Brook.</i>	Fitchburg, . .	Electricity, . .	24	4	182.0	500	7.55	-	S.	-	Static head, 188 feet; effective head assumed.
41	Sampson Cordage Company, . .	Shirley, . . .	Cordage, . . .	9	20	20.0	135	3.37	-	-	-	-
42	Sampson Cordage Company, . .	Shirley, . . .	-	-	19	12.0	90	4.34	-	-	-	Water power not used.
43	G. M. Ballou, ...	Shirley, . . .	Sawmill, . . .	9	19	10.0	80	4.03	-	None	-	-
44	F. D. Weeks Extracting Company, ...	Shirley, . . .	Shoddy, . . .	10	19	14.0	90	3.72	-	S.	-	-
45	Gould Manufacturing Company, ...	Shirley, . . .	Shoddy, . . .	9	14	18.0	125	5.45	-	None	-	-
46	<i>Squannacook River.</i> Groton Leather Board Company, ...	West Groton, . .	Paper, ...	24	71	15.0	250	2.58	-	S.	-	-
47	Hollingsworth & Vose Company, ...	West Groton, . .	Paper, ...	24	70	13.0	208	2.52	-	S.	-	-
48	Spaulding Brothers, ...	Townsend Harbor, . .	Fiber, ...	24	59	11.0	140	-	-	S.	-	-
49	<i>Nisisset River.</i> Nisisset Mills, ...	East Pepperell, . .	Paper, ...	24	60	-	-	-	-	-	-	-
	Total, ...	-	-	-	-	-	12,037	-	-	-	-	-

TABLE XXXIII. — *Principal Lakes and Ponds on the Nashua River in Massachusetts.*

[Except where otherwise noted, areas of ponds obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	<i>South Branch.</i> Wachusett Reservoir, . . .	Clinton, Sterling, Boylston and West Boylston.	Metropolitan Water and Sewerage Board.	118.0 ¹	4,135 ²	—	8,680.0	Metropolitan district water supply.
2	Pine Hill Reservoir, . . .	Holden, Paxton and Rut- land.	City of Worcester,	6.9	345 ²	—	400.0	Worcester water supply. Under construction.
3	Kendall Reservoir, . . .	Holden, . . .	City of Worcester,	2.5	175 ²	—	108.0	Worcester water supply.
4	<i>North Branch.</i> Nashua Reservoir, . . .	Ashburnham and Gardner,	Nashua River Reservoir Company.	3.6	212	8	49.0	—
5	South Ashburnham Reservoir,	Westminster, . . .	Nashua River Reservoir Company.	11.7	116 ²	25	52.0	Built about 1909; dam, 30 feet maximum height.
6	Round Meadow, one-half mile east of Westminster.	Westminster, . . .	—	4.3	63	7	13.0	Low dam, about 8 feet maximum height.
7	Wymann Reservoir, or Grass Pond.	Westminster, . . .	City of Fitchburg,	4.7 ²	255 ²	—	56.0	Compensating reservoir for benefit of mills.
8	Rice's Reservoir, . . .	Ashburnham, . . .	—	2.3	118	14	54.0	Earth dam, 250 feet long, 20 feet maximum height.
9	Meeting House Pond, . . .	Westminster, . . .	City of Fitchburg,	1.5	152 ²	—	87.5	Fitchburg water supply.
10	Wachusett Pond, . . .	Westminster and Princeton,	City of Fitchburg,	1.5	126 ²	—	43.7	Fitchburg water supply.
11	Scott's Reservoir, . . .	Fitchburg, . . .	City of Fitchburg,	—	35 ²	—	—	Fitchburg water supply.
12	Falulah Reservoir, . . .	Fitchburg, . . .	City of Fitchburg,	—	15 ²	—	—	Fitchburg water supply.
13	Overlook Reservoir, . . .	Fitchburg, . . .	City of Fitchburg,	—	13 ²	—	—	Fitchburg water supply.
14	Leominster Reservoir, . . .	Leominster and Fitchburg,	Association of mills,	3.7	208	—	—	—

Other Tribularies.		Association of mills,		15.3	386	16	170.0	Earth dam, 220 feet long, 20 feet maximum height.
15	Shirley Reservoir,	Lunenburg,	.	.				Amusement park on shores.
16	Whalom or Uncheohewaton Pond,	Lunenburg,	.	.	107			
17	Ashby Reservoir,	Ashby,	.	.	154*		93.5	Fitchburg water supply.
18	Bare Hill Pond,	Harvard,	.	.	330			
19	Sandy Pond,	Ayer,	.	.	74			
20	Fletcher Pond,	Ayer,	.	.	108			
21	Plow Shop Pond,	Ayer,	.	.	89			
22	Long Pond,	Ayer and Groton,	.	.	44			

¹ Total area tributary. Approximately 10 square miles diverted by city of Woroster, leaving net drainage area of 108.84 square miles.

2: Area from large scale plans or reliable local sources.

* Net drainage area. Water from Meeting House Pond and Wachusett Pond diverted for Fitchburg water supply.

CONCORD RIVER.

This river is formed by the union of the Assabet and Sudbury rivers, their junction being located in the town of Concord about three-fourths of a mile north of the main village street. The Assabet rises about 4 miles southwest of Westborough, and the Sudbury near Framingham. The former drains the rough and hilly portions of Shrewsbury, Westborough, Northborough, Berlin, Hudson and Clinton, on the easterly slope of the Nashua River divide; and the latter flows through meadows and swamps in Wayland, Sudbury and Lincoln to their junction in Concord. From this point the main or Concord River proper flows northerly for about $15\frac{1}{2}$ miles to its junction with the Merrimack River at Lowell.

The drainage basin of 402 square miles in area is about 39 miles long, and from 11 miles wide at the middle section to 19 miles wide in the vicinity of Framingham, where several reservoirs of the metropolitan water supply are located. It is for the most part very flat, containing much swamp and overflowed meadow land, but is hilly and broken on the southerly and westerly borders, along a part of the Assabet River, and again in the lower 5 miles between North Billerica and the mouth of the river. A change in the river bed occurs at North Billerica, below which boulders and ledge begin to appear, and the larger part of the fall in the river occurs in this section, which makes it available for water-power purposes. In the last mile and a quarter from the mouth, where the bed is very rocky and the banks are high, the fall is about 47 feet at the Wamesit Dam at the Lawrence Street bridge in Lowell. The portion of the stream between North Billerica and the junction of the Assabet, and continuing up the Sudbury River to Saxonville Mills, is very flat, the entire fall for a distance of about 29 miles being not over 2 feet.

The river bed is made up of sand and mud, the course is winding, and the current correspondingly sluggish, which keeps the broad meadows very wet the greater portion of the time. Its width varies from 125 to 300 feet.

The fall of 22 feet at Saxonville Village offers the only opportunity for water power on the Sudbury River; but the

power at this point is greatly reduced, as the basin above is mostly diverted for water-supply purposes, and only a stipulated amount of its yield with some surplus is available for power use.

The Assabet Basin, being more hilly and broken, has a more rapid fall with high banks, and therefore offers an opportunity for a series of small water powers between the towns of Concord and Northborough, most of which are fully utilized. The entire fall of the Assabet from its source in Westborough to the mouth is about 180 feet, 121 feet of which are developed to the extent of about 1,100 horsepower.

The area of the Concord watershed above the junction point of the Assabet and Sudbury rivers is about 340 square miles, of which 75.2 square miles have been diverted in the Sudbury basin by the Metropolitan Water and Sewerage Board, and 17.58 square miles in the Cochituate Basin, making altogether 92.78 square miles, used mostly for water supply.

The following list shows the cities and towns that are largely or partly drained by the Concord River and its tributaries, together with the population of each in the year 1915, except where only a very small part is within the drainage basin: —

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Aston, ...	2,151	Littleton, ...	1,228
Ashland, ...	2,005	Lowell, ...	107,978
Bedford, ...	1,365	Marlborough, ...	15,250
Berlin, ...	865	Maynard, ...	6,770
Billerica, ...	3,246	Natick, ...	11,119
Bolton, ...	768	Northborough, ...	1,797
Boxborough, ...	326	Sherborn, ...	1,696
Carlisle, ...	490	Shrewsbury, ...	2,794
Chelmsford, ...	5,182	Stow, ...	1,127
Clinton, ...	13,192	Sudbury, ...	1,206
Concord, ...	6,681	Tewksbury, ...	5,265
Framingham, ...	15,860	Wayland, ...	2,083
Hopkinton, ...	2,475	Westford, ...	2,848
Lincoln, ...	1,310		

Improvement of the Concord and Sudbury Rivers.

The work of dredging the river in order to drain off the wet meadows was assigned by the Legislature to the State Board of Health in 1894, and was completed in 1897. The result has been to materially improve the flow of the river, as well as lower the water table in the meadows. The Board, in a summary of work accomplished makes the following statement in regard to it: —

The Concord River and its main tributary, the Sudbury, drain an extensive area of level country in the east central part of Massachusetts, and the rivers are bordered for many miles of their courses by extensive meadows which were usually wet and often inundated, even in the summer season. Previous investigations had shown that the conditions would be materially improved by removing certain bars in these rivers which obstructed the flow, and in 1894 the State Board of Health was directed to expend \$20,000 in the improvement of these rivers by dredging and removing the bars which impeded the flow of the streams. The amount appropriated was subsequently increased to provide for additional work, including the reconstruction of a bridge, and the total expenditure was \$23,000. The work was completed in 1897, and the expected improvement in the condition of the adjacent meadows has been fully realized.

Water Power.

The larger part of the available water power of the Concord River is concentrated within the lower mile and a quarter from the mouth, and is now controlled by two companies, — the Middlesex and the Wamesit power companies. The former company, located on the east bank within a half mile of the mouth, is entitled to the first 176 second-feet of flow, which under a 13-foot head produce about 200 horsepower for two-thirds of the year. Five other companies on the opposite bank are entitled to the surplus flow after the first 176 second-feet, and use from the same dam, under a head of 11 to 12 feet, about 175 horsepower for about the same part of the year.

The Massic Falls Mills, whose privilege is located a short distance above the Middlesex Company, are now under the control of the Wamesit Power Company. One foot of flashboards is used most of the time, bringing the average head of $7\frac{1}{2}$ feet to about 8 feet.

About two-thirds of a mile above Massic Falls is the Lawrence Street Dam, built of wood and stone, and irregular in shape. Although only about 8 feet in height it produces, by means of a canal about 2,300 feet long, a head of 22 feet. The water power from this canal, known as the Wamesit Canal, is owned and distributed as follows: —

	Cubic Feet per Second.
American Woolen Company, ...	73
Stirling Mills (including Wood's grist mill), ...	48
American Bolt Company (controlled by the Wamesit Power Company), ...	48
Belvidere Mills No. 2, ...	27
Lowell Bleachery, ...	36
Wamesit Power Company, ...	68 ¹

The seven water wheels installed at a maximum capacity of 900 horsepower never use over 800 horsepower at any one time. The horsepowers developed during a low season are, for an occasional very dry month, 138 net horsepower; for lowest month in an average year, 326 net horsepower; for the second lowest month in an average year, 438 horsepower.

The only other hydraulic plant on the Concord River is at North Billerica, about 3 miles up-stream from the Wamesit Dam, and is owned by the Talbot Mills, Incorporated. Here a stone masonry dam 9 feet high, together with a canal about 400 feet long, produces a fall of from 10 to 11 feet, or an average of 10½ feet. There are four wheels installed with a total capacity of 362 horsepower, including a new 130-horsepower wheel which is replacing an old Swain wheel of 90 horsepower. A little more than half of the wheel capacity can be run throughout the year in favorable years only, and more than 200 horsepower for two-thirds of an average year. An auxiliary steam plant of 600 horsepower enables the company to tide over the dry periods, while their increased installation will enable them to utilize to a much larger extent the freshet flows when desirable. A considerable amount of the flow is used for mechanical purposes, such as washing, bleaching and dyeing.

On the easterly or right bank of the river the North Billerica Company, the proprietors of the Faulkner Mills, is located,

¹ And all surplus over a total of 288 cubic feet per second, which is the computed flow extending to an elevation even with the top of the dam.

which takes water from the same dam or flume, most of which is used for washing purposes. The company has, however, a 60-horsepower wheel, which is used to half capacity for the greater part of the year; also a steam auxiliary of 300 horsepower of which about 230 horsepower is used regularly.

Sudbury River.

On the Sudbury Branch of the Concord River the only water power is that of the Saxonville Mills, where there are two dams. One $1\frac{1}{2}$ feet in height only, located about a mile and a quarter above the mills, is used wholly to pond the water for better control at the mill. The other is a masonry dam producing through a head of 22 feet about 400 horsepower for about half the year, out of a maximum installation of 560 horsepower. This mill has the benefit of 1,500,000 gallons daily, released from Dam No. 1 of the metropolitan water supply, plus whatever surplus is wasted from the same, being a part of the yield from 75.2 square miles of diverted area which is mostly collected for the use of the metropolitan district. The uncontrolled area below Dam No. 1 is only 11.07 square miles. The mill has an auxiliary steam plant of 700 horsepower, of which over 400 is used regularly.

As required by chapter 177 of the Acts of 1872, a discharge from Reservoir No. 1 of not less than 1,500,000 gallons per day into Sudbury River has been maintained each year from 1875 to 1917, inclusive, or forty-three years. Additional water has been wasted over Dam No. 1 to keep the reservoirs at a proper operating level. The total average yearly amount wasted into Sudbury River from this source is 2,469,000,000 cubic feet, or 78.3 second-feet. This amount added to the yield of the uncontrolled area between Dam No. 1 and the Saxonville Mills, based on the average flow per square mile of the Concord River watershed, is sufficient to produce 190.5 horsepower continuously twenty-four hours each day, if the amount of water wasted had been evenly distributed. This horsepower reduced to a fifty-four-hour per week basis of utilization would amount to 508 horsepower, or, if pondage is utilized to store the Sunday flow, 595 horsepower. The present wheel capacity is 560 horsepower.

In addition to this contribution to the flow of the Sudbury River a yearly average of 323,500,000 cubic feet, or 10.25 second-feet, has been discharged from Lake Cochituate into the Sudbury River below the mills, of which 2.38 second-feet was originally from the yield of the Sudbury watershed, which was turned into Lake Cochituate by various channels for operating purposes, and is included in the estimated amount of discharge from Lake Cochituate.

If these two contributions of 88.55 second-feet are added to the mean flow of Concord River at Wamesit Dam it would be sufficient to produce 1,045 horsepower at 80 per cent. efficiency. The installed wheel capacity at this point is 900 horsepower, but the maximum amount used at any one time is 800 horsepower.

The above estimate of power value of the waste from Reservoir No. 1 and Lake Cochituate is based upon the same being evenly distributed, but as a matter of fact it is actually contributed very unevenly month by month, the larger part in the wettest months and very little in the dry months; and as it is but a small per cent. of the yield of the watersheds of the Merrimack River at Lawrence, it has been deducted in calculating the available flow of the river at that point.

Assabet River.

The distribution of the fall in this stream is somewhat irregular, amounting to about 100 feet in the upper 12 miles above Hudson and 18 feet only between Hudson and the top of the Assabet Dam at Maynard, — a distance of $7\frac{1}{2}$ miles, — and in the remaining 9 miles to the mouth there is a fall of about 66 feet.

There are ten dams or privileges on the river between West Concord and Northborough, owned by nine companies, with water powers varying from 25 to 300 horsepower. The two most important plants are the American Powder Company, near the corner of Acton, Concord and Maynard, and the Assabet Mills, at Maynard. The former, by reconstructing their flume in 1897, increased the head to 14 feet and the power to 277 horsepower, making use of the greater portion of it most of the time. They have an auxiliary steam plant of 300 horse-

power and run on a twenty-four-hour basis. The Assabet Mills at Maynard have two dams. The lower one has a head of 10 feet, but the wheel has been taken out and the lower mill is not running at present. The upper dam, which is some distance above the upper mill, is 8 feet high, and by means of a canal a head of 22 feet is obtained developing 300 horsepower. This mill was formerly a paper mill, but now produces woolen goods. It has a large steam auxiliary of 4,000 horsepower.

The company controls storage in Boone Pond and Fort Meadow Reservoir, the latter being used also for the joint benefit of the American Powder Company and the Strathmore Worsted Mills below. The former pond has a surface area of 109 acres and a storage capacity of 21,800,000 cubic feet, and Fort Meadow Reservoir has a surface area of 228 acres and a storage capacity of 45,700,000 cubic feet. These are the only storage reservoirs under regulated control in the basin, outside of the reservoirs used for water supply, but there are many other ponds which hold back the flow so as to make the run-off of the stream fairly regular.

The Hudson Counter Company at Hudson, leased from the W. H. Brigham Estate, furnishes power by connected shafting to three small companies. The dam has 3-foot flashboards giving a head of 13 feet and producing about 65 horsepower for two-thirds of the year. When the flow falls 3 inches below the top of the flashboards the wheels are shut off and steam power is used.

The principal water powers of the Concord, Sudbury and Assabet rivers are shown on Table No. XXXIV., on pages 211 to 213, and the principal lakes and ponds on Table No. XXXV., on pages 214 and 215.

TABLE XXXIV. — *Water Power on the Concord River in Massachusetts.*

[S. indicates steam; E., electricity.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
1	Middlesex Company, from same dam.	Lowell, . .	Power, . .	9	-	13.0	284	.780	300 S.	East bank. Entitled to first 176 second-feet of flow.
	Wamsitt Worsted Company,									
	New England Bunting Com-									
	United States Worsted Com-	Lowell, . .	-	9	308.42 ¹	11.5	175	.540	125 S. and E.	West bank. Entitled to surplus above first 176 second-feet.
2	Lowell Paper Company, . .									
	Bay State Dye House, . .									
	Wamsitt Power Company, Made Falls.	Lowell, . .	Power, . .	9	308.22	7.5	200	.960	-	Power furnished to small companies.

¹ Excluding diversions, 75.2 square miles in Sudbury; 17.98 square miles in Cochituate.

TABLE XXXIV. — *Water Power on the Concord River in Massachusetts* — Concluded.

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
3	American Woolen Company, Ray State Mills.	Lowell.	Power, woolen yarns and cloth.	9	283.72	23.0	900	1.585	1,400 S. 325 S.	American Woolen Company, 73 second-feet. Stirling Mills and Woods Grist Mill, 48 second-feet. United States Cartridge Company, 26 second-feet. Belvidere Mill No. 2, 27 second-feet.
	Woods Grist Mill.									
	United States Cartridge Company.									
4	Belvidere Woolen Company at Belvidere Mills No. 2.	Lowell.	Woolen goods.	9	277.30	10.5	352	1.387	600 S.	Lowell Bleachery, 26 second-feet. Wamselt Power Company, 68 second-feet and surplus above 288 second-feet.
	Lowell Bleachery.									
	Wamselt Power Company.									
5	Talbot Mills, Inc.	North Billerica.	Woolen goods.	9	277.30	10.5	60	.227	300 S.	-
	North Billerica Company (property Faulkner Mills).	North Billerica.	Woolen goods.	9	277.30	10.5	60	.227	300 S.	-
6	Sudbury River.	Saxonville.	Woolens and worsted.	9	11.07	22.0	560	-	700 S.	-
5a	Saxonville Mills Company.	Saxonville.	Woolens and worsted.	9	22.28	55.0	1,000	-	-	-
5b	Commonwealth of Massachusetts.	Southborough.	Electricity.	-	-	28.0	900	-	-	Electricity sold to Edison Electric Illuminating Company.

Assabet River.										
6	Strathmore Worsted Mill, . . .	West Concord, .	Worsted goods, .	-	118.10	10.0	150	1.400	300 S.	Formerly Concord Rubber Company.
7	American Powder Company, .	Acton, . . .	Powder, . . .	24	116.80	14.0	277	1.865	300 S.	-
8	Assabet Mills, ...	Maynard, .	Woolen goods, .	9	114.60	10.0	-	-	-	Wheel taken out.
9	Assabet Mills, ...	Maynard, .	Woolen goods, .	9	114.40	22.0	300	1.310	400 S.	Not using water power at present.
10	Gleasondale Woolen Mills, . .	Gleasondale, .	Woolen goods, .	9	77.90	12.0	120	1.410	160 S.	Owned by American Woolen Company.
11	Hudson Counter Company (W. H. Brigham Estate).	Hudson, . . .	Leather goods and fiber.	9	65.00	13.0	65	.846	60 S.	Furnish power via shafting to Novelty Paper Box Company, Machine Screw Company, Hudson Hunting Company.
12	Whittaker & Bacon, ...	Northborough, .	Shoddy mill, . . .	9	31.00	12.0	70	2.070	250 E.	Formerly E. W. Chapin.
13	Taylor Manufacturing Company, .	Northborough, .	Woolen goods, . .	9	30.70	12.0	58	1.780	135 E.	Formerly D. F. Woods.
14	Whittaker & Bacon, ...	Northborough, .	Shoddy mill, . . .	9	30.30	8.0	25	1.140	100 E.	Just being fitted up. Formerly W. M. Farwell & Co.
15	Hildreth Syndicate, ...	Northborough, .	Grit mill, ...	-	20.20	8.0	30	2.040	-	Runs only part of the time.
Total, ...				-	-	-	5,236	-	-	-

1 Excluding diversions, 75.2 square miles in Sudbury; 17.98 square miles in Cochituate.

TABLE XXXV. — *Principal Lakes and Ponds on the Concord River in Massachusetts.*

[Except where otherwise noted, areas of ponds are obtained from original plane table sheets of the State topographical map. Scale, 1:80,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Hart Pond,	South Chelmsford,	—	2.10	67	—	—	—
2	Nutting Pond,	South Billerica,	—	.85	67	—	—	—
3	Nagog Pond,	Acton,	—	1.83	284 ¹	—	—	—
4	Fort Pond,	Littleton,	—	2.96	85	—	—	—
5	Long Pond,	Littleton,	—	1.25	88	—	—	—
6	Lake Walden,	Concord,	—	.85	65 ¹	—	—	—
7	Heards Pond,	Wayland,	—	.54	83	—	—	—
8	Willis Pond,	Sudbury,	—	1.25	26	—	—	—
9	Puffers Pond,	Maynard and Sudbury,	—	.51	30 ¹	—	—	—
10	West Pond,	Bolton,	—	.56	15	—	—	—
11	Beons Pond,	Hudson and Stow,	Assabet Mills,	2.49	109 ¹	4	21,800	—
12	White Pond,	Hudson and Stow,	—	.41	40	—	—	—
13	Fort Meadow Reservoir,	Marlborough,	Assabet Mills,	4.03	307 ¹	4	173,800	—
14	Gates Pond,	Berlin,	—	.68	84 ¹	—	—	—
15	Williams Pond,	Marlborough,	—	.80	73 ¹	—	—	—

SHAWSHEEN RIVER.

The Shawsheen River rises in the towns of Bedford and Lexington, flows northeasterly and northerly for a distance of a little more than 20 miles, and empties into the Merrimack River at a point $1\frac{1}{2}$ miles below the Lawrence Dam. In its upper section, for a distance of about 10 miles above Ballardvale, the natural fall of the river is not over $3\frac{1}{2}$ feet per mile, whereas for a distance of about 4 miles below Ballardvale to a point one-half mile below Frye Village, where the Boston & Maine Railroad crosses the river, the fall is about 55 feet. The only water powers (four in number) on the river are located in this section, and they utilize a combined head of about 39 feet. The drainage area is narrow in proportion to its length, and contains 75 square miles of which 63 square miles are above the Ballardvale Dam. The larger part of the basin is quite flat, there being but two ponds or reservoirs of any considerable size to hold back the flow, Foster's Pond in Andover and Long Pond in Tewksbury. Both ponds together have a total storage capacity of about 44,000,000 cubic feet. The control of Foster's Pond, formerly operated jointly for the benefit of the mill owners below, was recently sold to Homer K. Foster, as it was not considered of sufficient benefit to warrant the expense of operation and maintenance.

Surveys and studies were made at one time for a water supply basin of about 214,000,000 cubic feet capacity, in the town of Billerica for the city of Boston, the dam to be above the crossing of the old Middlesex Canal; but it was never needed on account of the metropolitan development of the Wachusett water supply.

The following list shows the cities and towns that are largely or partly drained by the Shawsheen River, and the population of each for the year 1915 is given except where only a small part is within the drainage area:—

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Andover, ...	7,978	Lawrence, ...	-
Bedford, ...	1,365	Lexington, ...	5,538
Billerica, ...	3,246	Tewksbury, ...	5,265
Burlington, ...	751	Wilmington, ...	-

Water Power.

The average flow of the basin was assumed as 1.55 second-feet per square mile in arriving at the figures given in Table No. XXXVI., on page 218. The flow of the stream appears to be good for about eight months of the year. At the Ballardvale Mills two wheels aggregating 100 horsepower under 11 feet head utilize all the normal flow, with no margin for use of flood periods. At the next plant below, the Smith & Dove Manufacturing Company, producing linen thread and twine, the water power has recently been readjusted so that four wheels under 12 feet head develop about 300 horsepower for about eight months in the year, and a steam plant has been increased to 1,200 horsepower. At the Marland Mills about an equal amount of steam and water power is used, the installation being for a small amount in excess of the normal requirements. The lower mill on the stream at Frye Village, now producing brushes and baskets, uses from 30 to 35 horsepower of their installed capacity of 50 horsepower, and supplement it with a 35-horsepower oil engine in the dry season.

Table No. XXXVII., on page 219, gives the principal lakes and ponds on the Shawsheen watershed, with data regarding their use for storage purposes.

TABLE XXXVI. — *Water Power on the Shawsheen River in Massachusetts.*

[B. indicates steam.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile 80 Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
1	American Woolen Company (H. P. Binney, Trustee).	Frye Village, Andover.	Machinery, brushes and basted.	9	71.0	6.0	50	1.29	35 B.	Oil engine.
2	M. T. Stevens & Sons (Marland Mills), . .	Andover, ...	Woolen dress goods, .	9	68.0	9.5	160	2.73	150 B.	-
3	Smith & Dove Manufacturing Company, . .	Andover, ...	Linen thread and twine,	9	67.6	12.0	300	4.07	1,200 B.	-
4	Ballardvale Mills Company, ...	Ballardvale, . . .	Woolen goods (mostly white), .	9	63.0	11.0	100	1.59	125	-
	Total, ...	-	-	-	-	-	610	-	-	-

Total drainage area at mouth, 75 square miles.

TABLE XXXVII. — *Principal Lakes and Ponds on the Shawheen River in Massachusetts.*

[Except where otherwise noted, areas of ponds are obtained from the original plane table sheets of the State topographical map. Scale, 1: 30,000.]

No.	NAME OF POND.	Location.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Foster's Pond,	Andover, .	Homer K. Foster, .	2.38	128 ¹	12	27.9	- - -
2	Long Pond, .	Tewksbury, .	Ballardvale Mills Company,	1.83	64 ¹	6	15.7	Ballardvale Mills Company has abandoned regu- lated control of flow from these ponds recently.

¹ Area obtained from reliable source.

POWOW RIVER.

This stream rises in the town of Kingston, N. H., and flows by a very crooked course in a southeasterly and southerly direction until it finally joins the Merrimack River by a rather long tidal estuary, at a sharp bend opposite the northerly point of Newburyport. The basin is about 10 miles northwest and southeast, and about 4 to 6 miles wide, and has a drainage area above Gardner Lake of about 51 square miles. The average rainfall from 1893 to 1913 was 39.8 inches.

The basin is thinly settled, except for the village of Amesbury, near the mouth, which has about 8,500 inhabitants and a number of mills and factories. The general slope of the basin is rather flat, although dotted here and there with hills about 300 feet high, and the soil is sandy. It contains eleven ponds and reservoirs of sufficient storage capacity to produce a very even and serviceable flow, which develops considerable water power due to the fact that the fall or head is concentrated within a half mile of the outlet of Gardner Lake, the lowest pond in the system.

The total fall between East Kingston and the mouth, a distance of $9\frac{1}{2}$ miles, has been computed by Professor Porter to be about 122 feet, of which about 85 feet occur within a half mile of Gardner Lake as above mentioned, where the actual developed head is 81 feet. The total area of all the ponds is over 2,200 acres, and the total storage, not including Gardner Lake is estimated at over 437,900,000 cubic feet, which is all under the control of one company.

There are only two towns in Massachusetts within the basin, namely, Amesbury and Merrimack, the former with a population in 1915 of 8,543, and the latter, 2,101. The rest of the basin is within the State of New Hampshire in Rockingham County, and includes parts of Danville, Sandown, Hampsted, Kingston, East Kingston, Newton and South Hampton.

Water Power.

The Merrimack Valley Power and Buildings Company is the sole owner of the water privilege, having bought the same from the Hamilton Woolen Company in 1916. The entire system of

power has been remodeled within the past two years, so as to get the full benefit of all the yield of the basin by means of nearly complete regulation. The whole system is tied together electrically so that a single control is maintained at the new power station some distance below the lower dam, with no operators in attendance at Gardner Lake or other points.

Formerly the power was obtained from six dams built very near together, with Gardner Lake used for storage only, being drawn down by day and refilled or partly refilled at night, so that the total installed capacity of 1,000 horsepower was only available for about three months of the year. At present, as redeveloped, power is created by two dams below Gardner Lake, the nearer supplying a 1,000-horsepower turbine under 65 feet head, and a 350-horsepower turbine under 23 feet head. The former develops its high head at the power station by means of a penstock which by-passes the second dam below. The second or lower dam supplies a 500-horsepower turbine under 29 feet head. Another turbine has been installed at Gardner Lake Dam, which develops 220 horsepower under 16 feet head, and is operated by an automatic electrical control at the power station, so that it acts as an outlet or control gate for the lake, in place of the old gate house which formerly required an attendant. Only the top foot of the lake is drawn from, so as to give continuous flow for twenty-four hours each day. The turbine at Gardner Lake and the 1,000-horsepower unit are ordinarily operated together, both using the same amount of water, and the 350-horsepower and 500-horsepower units are operated during periods of excess flow.

The company maintains a steam plant of 2,000 horsepower and is tied in electrically with the Newburyport Gas and Electric Light Company by means of a transmission line $5\frac{1}{2}$ miles long and 2,000 K. W. capacity. The company supplies its tenants, about 12 in number, with light and power, and also supplies the current used by the Amesbury Electric Light Company.

Table No. XXXVIII., on page 222, shows the details of the water powers, and Table No. XXXIX., on page 223, the principal lakes and ponds, with various details.

TABLE XXXVIII. — *Water Power on the Pouow River in Massachusetts.*

[S. indicates steam; E., electricity.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile 80 Per Cent. Efficiency.	Auxiliary Horsepower.
1							500	3.74	2,000 S.
2	Merrimac Valley Power and Buildings Company, . . .	Amesbury, . . .	Light and power, . . .	24	50.63	65	1,000	3.35	2,000 K. W. E.
3						23	350	3.31	-
						16	220	2.99	-
	Total, ...	-	-	-	-	-	2,070	-	-

TABLE XXXIX. — *Principal Lakes and Ponds on the Powow River in Massachusetts and New Hampshire.*
 [Except where otherwise noted, areas are obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Angle Pond, . . .	Hampstead-Sandown, N. H.,	-	2.02	81	-	-	-
2	Cub Pond, . . .	Danville-Sandown, N. H.,	-	.84	45	-	-	-
3	Long Pond, . . .	Danville-Kingston, N. H.,	-	4.10	87 ¹	5.5	20.80	-
4	Little Kingston, . . .	Kingston, N. H., . . .	-	1.36	81 ¹	5.0	10.55	-
5	Great Kingston, . . .	Kingston, N. H., . . .	-	9.43	290 ¹	5.0	63.00	-
6	Country Pond, . . .	Kingston-Newton, N. H.,	-	16.85	600 ¹	4.5	115.00	Total storage, 437,900,000 cubic feet.
7	Trickling Falls Pond, . . .	East Kingston, N. H., . . .	Merrimac Valley Power and Buildings Company.	35.50	467 ¹	7.5	90.00	-
8	Tuxbury Pond, . . .	South Hampton, N. H.,	-	-	150 ¹	7.5	32.00	-
9	Coombs Pond, . . .	East Kingston, N. H., . . .	-	-	75 ¹	3.0	9.50	-
10	Lake Attitash, . . .	Amesbury-Merrimac, . . .	-	46.80	360 ¹	8.0	97.00	Kimballa Pond. Includes Tuxbury and Coombs.
11	Gardner Lake, . . .	Amesbury, . . .	-	51.00	80 ¹	8.0	20.00	-

¹ Obtained from reliable local sources.

SPICKET RIVER.

This small stream has its chief source in Island Pond, which is located in the towns of Derry and Hampstead, N. H. It flows southerly and southeasterly for a distance of about 15 miles, and empties into the Merrimack River at Lawrence.

The drainage area is 78 square miles, all but 10 of which are within the State of New Hampshire where all the storage is located, there being nine ponds having an aggregate area of about 1,500 acres, two of which — Island Pond and Canobie Lake — cover about 930 acres and furnish the principal storage. A new dam has been built on the outlet of Hitytity Pond, making a fair-sized reservoir. All the storage is under control of the Arlington Mills in Methuen.

The total fall in the river is about 160 feet, about 80 feet of which occur within the $3\frac{1}{2}$ miles of the mouth, where there is an aggregate developed head of 72 feet.

The following is a list of the cities and towns that are largely or partly drained by the Spicket River, and the population in 1915 of those within the State of Massachusetts: —

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Derry, N. H., ...	-	Pelham, N. H., ...	-
Hampstead, N. H., ...	-	Salem, N. H., ...	-
Windham, N. H., ...	-	Methuen, Mass., ...	14,007
Atkinson, N. H., ...	-	Lawrence, Mass., ...	90,259

The average rainfall is between 40 and 42 inches, and the average run-off of the basin is a little under 50 per cent. of the rainfall.

Water Power.

There are only four water powers in Massachusetts, as shown in Table No. XL., on page 226. The largest use of the flow is made by the Methuen Company's cotton mills, where the installed capacity of the water wheels is about 600 horsepower, used under a head of $40\frac{1}{2}$ feet. There is nearly the same amount of horsepower of steam in reserve for the dry season.

The Arlington Mills, which really control the flow of the stream, use the water mostly for washing, bleaching, etc. Formerly but 20 horsepower of water power under a head of $11\frac{1}{2}$ feet was used for electric lighting purposes. It is understood that, with the more recent improvement of the storage since the building of the new dam on the Hitytity outlet, a much greater use of the water power is contemplated.

There are two other small privileges on the lower part of the stream, — the Methuen Organ Company, and the Globe Worsted Mill Company, the latter within about 600 feet of the mouth. There is one other small dam and privilege at North Salem, N. H., about 10 miles up-stream from the Methuen Company's plant. The latter has a pondage extending along the bed of the river about $3\frac{1}{2}$ miles up-stream, which, by filling up at night, gives them a better chance for operation during the day.

The summer flow of the stream is naturally variable and quite small, necessitating the use of steam to a large extent; but the better regulation above referred to will more nearly equalize the yearly flow.

Table No. XLI., on page 227, gives a list of the principal lakes and ponds, together with other details.

TABLE XL. — *Water Power on the Spicket River in Massachusetts.*

[S. indicates steam.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet Per Square Mile, 80 Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
1	Globe Worsted Mill Company, . .	Methuen, . .	Worsted goods, . .	9	78.0	9.0	60	.940	100 S.	- - -
2	Arlington Mills, ...	Methuen, . .	Cotton goods, . .	9	76.2	11.5	20	.280	5,000 S.	Turbine used for electric light. Use water for washing, bleaching, etc.
3	Methuen Organ Company, . .	Methuen, . .	Organs, ...	9	74.4	11.0	50	.643	-	- - -
4	Methuen Company, ...	Methuen, . .	Cotton goods, . .	9	73.8	40.5	600	2,206	500	- - -
	Total, ...	-	-	-	-	-	730	-	-	- - -

TABLE XLI. — *Principal Lakes and Ponds on the Spicket River in Massachusetts and New Hampshire.*
 [Except where otherwise noted, areas are obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Wash Pond, ...	Hampstead, N. H., . . .	—	1.20	140	—	—	—
2	Inland Pond, ...	Derry-Hampstead, N. H., .	—	17.40	480	6	100.0	—
3	Hityity Pond, ...	Salem, N. H., ...	Arlington Mills Company, .	8.80	—	—	—	—
4	Captain Pond, ...	Salem, N. H., ...	Arlington Mills Company, .	.94	99	—	—	—
5	Junction Spicket River and Hityity Brook,	Salem, N. H., ...	—	43.70	—	—	—	No pond here.
6	Canobie Lake, ...	Salem-Windham, N. H., .	Arlington Mills Company, .	2.70	450	8	125.0	—
7	World End Pond, ...	Salem, N. H., ...	—	.94	60	—	—	—
8	North Pond, ...	Pelham, N. H., ...	—	1.15	40	—	—	—
9	South Pond, ...	Methuen, Mass., ...	—	.83	85	—	—	—
10	Methuen Company, ...	Methuen, Mass., ...	—	78.80	—	—	—	—

TABLE XL. — *Water Power on the Spicket River in Massachusetts.*

[S. indicates steam.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
1	Globe Worsted Mill Company, .	Methuen, .	Worsted goods, .	9	76.0	9.0	60	.940	100 S.	-
2	Arlington Mills, ...	Methuen, .	Cotton goods, .	9	76.2	11.5	20	.250	5,000 S.	Turbine used for electric light. Use water for washing, bleaching, etc.
3	Methuen Organ Company, .	Methuen, .	Organs, ...	9	74.4	11.0	50	.643	-	-
4	Methuen Company, ...	Methuen, .	Cotton goods, .	9	73.8	40.5	600	2.205	500	-
	Total, ...	-	-	-	-	-	730	-	-	-

TABLE XLI. — *Principal Lakes and Ponds on the Spicket River in Massachusetts and New Hampshire.*
 [Except where otherwise noted, areas are obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Wash Pond, ...	Hampstead, N. H., . . .	-	1.20	140	-	-	-
2	Island Pond, ...	Derry-Hampstead, N. H.,	-	17.40	480	6	100.0	-
3	Hityity Pond, ...	Salem, N. H., ...	Arlington Mills Company, .	8.80	-	-	-	-
4	Captain Pond, ...	Salem, N. H., ...	Arlington Mills Company, .	.94	99	-	-	-
5	Junction Spicket River and Hityity Brook,	Salem, N. H., ...	-	43.70	-	-	-	No pond here.
6	Canobie Lake, ...	Salem-Windham, N. H., .	Arlington Mills Company, .	2.70	450	8	125.0	-
7	World End Pond, ...	Salem, N. H., ...	-	.84	60	-	-	-
8	North Pond, ...	Pelham, N. H., ...	-	1.35	40	-	-	-
9	South Pond, ...	Methuen, Mass., ...	-	.83	85	-	-	-
10	Methuen Company, ...	Methuen, Mass., ...	-	78.80	-	-	-	-

IPSWICH RIVER.

The Ipswich River rises in Burlington in Middlesex County and flows in a generally easterly direction to the Atlantic Ocean, which it enters at the town of Ipswich. Its total drainage area is about 147 square miles, and its length about 32 miles.

The basin as a whole is very flat, even the highest hills not rising to an altitude greater than 400 feet. The stream flows for much of its course through marshy meadows with little fall and sluggish current.

The following cities and towns are wholly or in part within the watershed of this river:—

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Andover, ...	7,978	Middleton, ...	1,308
Beverly, ...	22,989	North Reading, ...	1,288
Boxford, ...	714	North Andover, ...	5,966
Burlington, ...	781	Peabody, ...	18,635
Danvers, ...	11,177	Reading, ...	6,805
Hamilton, ...	1,879	Topsfield, ...	1,173
Ipswich, ...	6,272	Wenham, ...	1,068
Lynnfield, ...	1,112	Wilmington, ...	2,320

At the head of tidewater in Ipswich there is a dam with a fall ranging from 6 feet to nothing, according to the stage of tide. This privilege was once used for a sawmill, but has been idle for some time. The next dam belongs to the Ipswich Mills, and is also in Ipswich. It provides an effective head of about 8 feet, which includes 18 inches of flashboards. The mill is equipped with water wheels whose capacity is estimated at from 150 to 200 horsepower, which is used as an auxiliary to a modern steam plant of 1,200 horsepower capacity.

Above this there are three low head privileges on the main river, the first being about 2 miles above the Ipswich Mills east of Mill Road at the Hamilton town line where a dam about 7 feet high is used to develop water power at a saw and

grist mill owned by W. J. Norwood; the second is located west of the Willowdale Road at the Hamilton town line, where there is a dam about 6 feet high which is not in use at present; the third dam is at the site of the former Middleton Paper Company near the Paper Mill station on the Salem & Lowell branch of the Boston & Maine Railroad, where a head of 10 feet was formerly obtained but is also idle at the present time. Between these privileges the river flows with a sluggish current, and has a slope of less than 3 feet per mile.

The sole industrial use of importance to which the water of the river is now put is for dyeing and bleaching in the manufacture of hosiery at the Ipswich Mills in Ipswich. It is stated in the first annual report of the Salem & Beverly Water Supply Board that the probable use of water at this mill for manufacturing purposes does not exceed 4,000,000 gallons per day, equivalent to 6.2 cubic feet per second. The yield of the Ipswich River in the future must primarily be used for public water supplies, and there appears to be no alternative to this conclusion, except the entrance of the surrounding towns into the metropolitan district.

The water-supply situation in Salem and Beverly assumed a critical condition in 1911, when it became evident that these cities were rapidly outgrowing the supply then used jointly. By chapter 54 of the Resolves of 1911 the State Board of Health was directed to investigate and report upon the matter of a water supply for the cities of Salem and Beverly and the town of Peabody, to be taken from the Ipswich River or any of its tributaries, or from such other sources as the Board might find available. A final report of the State Board of Health was published as House Document No. 1652 in January, 1912. As the result of this report, by chapter 85 of the Resolves of 1912 the Governor was directed within thirty days to appoint a commission of three persons to investigate the matter of a water supply for the cities of Salem, Beverly and Woburn, and for the towns of Burlington, Billerica, Tewksbury, Wilmington, Reading, North Reading, Andover, North Andover, Lynnfield, Peabody, Danvers, Wenham, Hamilton, Topsfield, Boxford, Georgetown, Ipswich and Rowley. This commission was composed of Thomas W. Proctor, John F. McDonald and Charles

R. Gow, and they made their report to the Legislature in March, 1913, House Document No. 2200.

As a result of the recommendations of this commission a board was created by chapter 700 of the Acts of 1913, to be known as the Salem and Beverly Water Supply Board, which was granted the right to divert water from the Ipswich River for the benefit of these two cities. This diversion was limited to the excess flow of the river above 20,000,000 gallons per day, to be taken only during the months of December to May, inclusive, and the aggregate amount to be diverted in any one calendar year was not to exceed 2,500,000,000 gallons.

Mr. Nathan Matthews was made chairman of this new Board, which issued its first annual report in 1915.

Briefly reviewing these three investigations, the State Board of Health in its 1912 report concluded that the creation of storage reservoirs on the Ipswich River was not feasible, and recommended that Salem sell to Beverly its share in the present Salem and Beverly water supply system, and that Salem should acquire its supply from the metropolitan system. The special commission appointed in 1912 employed Mr. Guy C. Emerson as engineer and Mr. Allen Hazen of New York as consulting engineer, and their report recommended that the Ipswich River be developed for the supply of both these cities. At that time Salem and Beverly took their entire supply from Wenham Lake and Longham Reservoir, and had a right to the use of Norwood and Beaver ponds on the Miles River; but these supplies were incapable of further development. Therefore, the special commission recommended that the supply be augmented by pumping from the Ipswich River into Wenham Lake during the time of high flows, thus assuring that the lake would be full each spring. They also favorably considered the creation of a large reservoir flowing the Wenham Swamp, though stating that "it does not appear to this commission that the probable expense of such a development can be justified at the present time, if apportioned only among four municipalities."

Under the act of 1913, which authorized the Salem & Beverly Water Supply Board to divert water from the Ipswich River, a canal was dug through which the water flows from the Ipswich River to the eastern edge of the Wenham Swamp, from which

point it is pumped through a short pipe line to Wenham Lake, which is at a slightly higher elevation.

The Salem and Beverly water supply as thus enlarged is estimated to be sufficient for the needs of the two cities for the next six to ten years. At that time an additional supply will be required, and this can be obtained either by additional storage or by a change in the restrictions under which water can be diverted from the Ipswich River. The Salem and Beverly Water Supply Board in its 1915 report was strongly of the opinion that the present restrictions on the use of the Ipswich River water are unreasonable, and the statement is made that if the laws are properly modified no storage will be required for many years to come.

No estimate is made as to how long these cities can be taken care of under more liberal restrictions, but presumably a time may come when storage will be required, and a careful investigation of the storage possibilities including several surveys was made under the direction of the joint board, and is fully discussed in its report.

The two most favorable possibilities are described under projects (c) and (e) on page 233, and are the same as those referred to as No. 7 and No. 9 on page 235.

One proposition consisted of building two dams, one on Nichols Brook and the other near Putnamville, creating two reservoirs which would unite to form one reservoir at the higher levels. It was estimated that these two reservoirs would cost \$756,000, and store approximately 4,000,000,000 gallons. The reservoirs were to be filled by pumping water from the river during the wet season, which would increase the water supply to 13.8 million gallons per day under the present restrictions. The present requirements are about 6,000,000 gallons per day.

The other storage proposition consisted of building a large reservoir covering the Wenham Swamp, as suggested in the sub-committee's report of 1913. A dam could be built at what is called the Lawrence site, about 2,000 feet above the Lamson Bridge, which would create a reservoir with the flow line at elevation 32, covering about 2,200 acres and holding 2,100,000,000 gallons. This would provide a total yield of 30,000,000 gallons per day, and allowing 10,000,000 gallons to flow down

stream for the benefit of the mills at Ipswich, would leave a yield of 20,000,000 gallons per day for municipal water supplies. The cost of such a reservoir based upon complete surveys and borings was estimated at \$1,120,000. It was also determined that the water level could be raised at some future time to elevation 35, increasing the area of the reservoir to 3,139 acres, and affording a total yield of 46,000,000 gallons per day at an additional cost of \$662,000, making the total cost of reservoir to elevation 35, \$1,782,000. The reservoir could be raised again to elevation 40, providing a total yield of 70,000,000 gallons at a total estimated cost \$2,242,500, and a still higher level could be obtained affording sufficient storage to make the entire yield of the Ipswich River available if desired.

The most complete use of the Ipswich River can only be brought about by the creation of a storage reservoir flooding the Wenham Swamp. The Nichols Brook and Putnamville sites could be used, which would give sufficient storage to provide for Salem and Beverly for many years to come, but when their capacity was outgrown it would then be necessary to build additional small reservoirs or go to the Wenham Swamp, and if the Wenham Reservoir is built the Nichols Brook and Putnamville reservoirs would become useless.

The storage situation is summed up by Mr. Allen Hazen, the consulting engineer of the joint board, as follows:—

Wenham Lake and Longham Pond now provide an available storage of about 855,000,000 gallons. By deeper drawing with a new intake this can be increased to 1,267,000,000 gallons. Under the present conditions this storage is refilled in wet years but not in dry years. With the Ipswich River diverted by the proposed canal and aqueduct, the storage would be refilled every year. Under these conditions the supply could be maintained for some years without additional storage.

The question of securing additional storage is, therefore, for the future, but it must be considered at this time so far as necessary to make sure that the works now proposed will be appropriate for a considerable development.

Several possible sites for reservoirs to increase storage have been considered, including the following:—

(a) Increasing the Longham storage by the construction of a new dam lower down, giving an available increase of 215,000,000 gallons.

(b) Putnamville Reservoir, giving an additional storage of 1,500,000,000 gallons.

(c) Nichols Brook, to be built in conjunction with the Putnamville Reservoir, making an available additional storage, including Putnamville, of 4,000,000,000 gallons.

(d) A reservoir on the main stream of the Ipswich River, formed by a dam above the Newburyport Turnpike, which could be built to hold as much as 14,500,000,000 gallons.

(e) A reservoir formed by a dam on the main stream of the Ipswich River at a point about 2 miles above the Willowdale Dam, where there is a favorable site. This last is sufficient to furnish storage for a complete development of the Ipswich River watershed, and would furnish a supply in dry years of 80,000,000, to 90,000,000 gallons per day; but to carry it out involves acquiring a great deal of valuable property, additional legislative authority, and the construction of expensive works, and this project is, therefore, one for the comparatively remote future, and not for immediate consideration.¹

The Salem and Beverly Water Supply Board in its report has the following to say regarding the limitations contained in the act of 1913 and the necessity for additional storage:—

There would be no necessity for artificial storage except for the limitations contained in the act of 1913 on the use of the waters of the Ipswich River.

The flow of the river is extremely fluctuating, as is shown by the data collected by the State Department of Health and herewith printed as Appendix 9. It will be seen that at the Newburyport Turnpike the daily flow varies from one-half of a million gallons to 1,200 million gallons per day, and at the mouth of the river, or the dam of the Ipswich Mills, from 1 million gallons to 2,400 million gallons per day. On 1,124 days during the period of 1,438 days covered by these tables the flow was over 10 million gallons per day at the Newburyport Turnpike; on 951 days it was over 20 million gallons; on 678 days, over 50 million gallons; and on 445 days, over 100 million gallons per day; and proportionately more (about 100 per cent.) at the mouth of the river.

The only persons specially interested in the flow of the river below the Newburyport Turnpike are the owners of the mill privileges near its mouth, particularly the Ipswich Mills. The use of water for power by this concern is inconsiderable, but it uses a certain quantity for cleansing. The Board understands that the maximum consumption by these mills of water for all purposes is about 4 million gallons per day.

It is obvious that the Legislature might well prohibit the Board from drawing water from the river at the time when it is flowing so slowly as to make further drafts a cause of serious damage to the mills; but it is equally plain that at all seasons of the year there are days on which an enormous quantity of water goes to waste in Ipswich Bay, and that the restrictions

¹ First Annual Report, Salem and Beverly Water Supply Board, pp. 102, 103.

inserted in the act of 1913 are out of all proportion to the possible requirements of the mills at any time.

The restrictions are three in number; and, in the opinion of the Board, all of them are unreasonable.

First, the total amount of water which can be drawn from the river during the year is limited to 2,500 million gallons. There is no reason for this limitation except that it must have been assumed that this was all the water the Board would want. The limit might have been put at 5,000 million gallons, or omitted altogether, without conceivable injury to any one, provided a proper minimum flow was conserved.

The second restriction is that the Board shall not divert water from the river unless it is flowing in excess of 20 million gallons per day. Previous to the passage of this act the most that had ever been suggested at this part of the river, viz., at the Newburyport Turnpike, as a proper minimum flow upon which no encroachment should be made for water-supply purposes, was 10 million gallons daily. See the special report of the State Board of Health, dated Jan. 10, 1912, and the report of the special commission of 1912-13, upon the strength of which the act in question was passed. The records (Appendix 9) show that during the 1,438 days covered by the same there were 173 on which the river flow at the Newburyport Turnpike was between 10 and 20 million gallons. Inasmuch as the maximum requirements of the mills below this point along the river do not exceed 4 million gallons per day, it would seem that the opinion of the State Board of Health and the special commission of 1912-13, that the proper minimum flow was 10 million gallons, should have been followed by the Legislature of 1913, and that the Salem and Beverly Board should have been authorized to pump whenever the daily flow was in excess of that quantity. This increase in the minimum flow from 10 to 20 million gallons daily would not affect the operations of the Board much if it could draw water throughout the year; but, in view of the fact that the Board cannot pump at all during the summer months, it may impair the utility of the Ipswich River supply to some extent.

The third and most onerous restriction is that no water at all shall be pumped between June 1 and December 1 of any year. This restriction seems absolutely unnecessary in the interests either of the riparian owners or of the mills below the point of diversion. The Board is unable to discover any reason why the surplus flow of the river at any period of the year which is in excess of all riparian requirements, and which would otherwise go to waste in Ipswich Bay, should not be diverted from the watershed at the Newburyport Turnpike for other and paramount needs, such as the water supply of neighboring towns and cities.

These restrictions, particularly the third, are so far beyond all the reasonable requirements of the riparian owners on the Ipswich River as to give the impression that they were insisted on by the representatives and property owners of the so-called valley towns in complete ignorance of the characteristics of their own river.

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The conclusion reached by the Board on the question of storage is that when storage becomes necessary, if it ever does, the best scheme in the light of present information would be either that numbered 7, or that numbered 9; but, as previously indicated, the Board is strongly of the opinion that the restrictions on the use of the river water should be modified so as to avoid artificial storage altogether, except in connection with some general conservation scheme.¹

Table No. XLII., on page 236, shows the details of the water powers, and Table No. XLIII., on pages 237 and 238, gives the principal lakes and ponds, with various details.

¹ First annual report, Salem and Beverly Water Supply Board, pp. 23-25, 32, 33.

TABLE XLII. — *Water Power on the Ipswich River in Massachusetts.*

[S. indicates steam.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet Per Square Mile, 80 Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
1	Ipswich Mills, . . .	Ipswich, . . .	Hosiery, .	24	147.3	8	175 ¹	1.63	1,200 S.	Water also used for bleaching and dyeing.
2	W. J. Norwood, . . .	Ipswich, . . .	Lumber, .	9	130.0	7	Low	-	-	-
3	Charles D. Rice, . . .	Willowdale Road, .	- - -	9	125.0	6	Low	-	-	Not in use.
4	Middleton Paper Company, .	Paper Mill station, .	Paper, .	-	45.0	10	Low	-	-	Not in use.

¹ Estimated.

Above No. 4 are 26 small privileges on tributaries, with heads varying from 4 to 20 feet.

TABLE XLIII. — *Principal Lakes and Ponds on the Ipswich River in Massachusetts.*

[Except where otherwise noted, the areas of ponds are obtained from original plane table sheets of the State topographical map. Scale, 1: 30,000.]

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Spofford's Pond, . . .	Boxford, . . .	Charles H. Chaplin, . . .	.29	27	5.5	Storage for power.
2	Four Mile Pond, . . .	Boxford, . . .	Charles H. Chaplin, . . .	1.12	54	14.5	Storage for power.
3	Wood or Cadet Pond, . . .	Boxford, . . .	Charles H. Chaplin, . . .	2.63	22	7.8	Storage for power.
4	Hoods Pond, . . .	Ipswich and Topsfield, . . .	Commonwealth of Massachusetts, . . .	2.20	67 ¹	23.4	-
5	Stiles Pond, . . .	Boxford, . . .	W. K. Cole, . . .	.77	60	19.0	Storage for cranberry bog.
6	Cedar Pond, . . .	Boxford, . . .	Commonwealth of Massachusetts, . . .	.21	12	3.4	-
7	Pond below Cedar, . . .	Boxford, . . .	Commonwealth of Massachusetts, . . .	.71	10	2.6	-
8	Crooked Pond, . . .	Boxford, . . .	Commonwealth of Massachusetts, . . .	.14	15	4.5	-
9	Pond near Ingalls station, . . .	North Andover and Middle- ton, . . .	-	.92	10	3.4	-
10	Swan Pond, . . .	North Reading, . . .	-	.14	45	37.5	Diverted for water supply, Danvers, Middleton and North Reading.
11	Middleton or Forest Pond, . . .	Middleton, . . .	-	1.62	95 ¹	42.7	Diverted for water supply. Danvers and Middleton.

¹ Obtained from plan or reliable source.

TABLE XLIII. — *Principal Lakes and Ponds on the Ipswich River in Massachusetts — Concluded.*

No.	NAME OF POND.	Town.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Esti- mated Storage (Million Cubic Feet).	Remarks.
12	Martins Pond, . . .	North Reading, . . .	- . . -	7.64	100	59.2	Reserved for water supply, Lynn
13	Suntaug Lake, . . .	Lynnfield and Peabody, . . .	- . . -	.70	157 ¹	65.0	and North Reading. Diverted for water supply, Peabody.
14	Winous Pond, . . .	Peabody, . . .	Charles Brown, . . .	1.70	28	6.0	Ice. Drainage area includes Suntaug.
15	Crystal Pond, . . .	Peabody, . . .	Englewood Association, . . .	.43	14	3.1	- . . -
16	Wenham Lake, . . .	Beverly and Wenham, . . .	- . . -	2.61	251 ¹	268.0	Diverted for water supply, Salem
17	Muddy Pond, . . .	Wenham, . . .	Commonwealth of Massachusetts, . . .	.18	18	1.5	and Beverly. . . -
18	Pleasant Pond, . . .	Hamilton and Wenham, . . .	Commonwealth of Massachusetts, . . .	.57	43	7.0	- . . -
19	Longham Reservoir, . . .	Wenham, . . .	- . . -	3.07	43 ¹	7.5	Diverted for water supply, Salem
20	Beaver Pond, . . .	Beverly, . . .	A. M. Haskell, . . .	1.81	43	4.4	and Beverly. . . -
21	Silver Lake, . . .	Wilmington, . . .	- . . -	.95	15	14.0	Ice.

¹ Obtained from plan or reliable source.

Total drainage area diverted for water supply, 15.8 square miles.

CHARLES RIVER.

The Charles River has its source in the town of Hopkinton about 25 miles southwest of Boston. Thence it pursues an extremely crooked course for much of its length, frequently winding back and forth in long loops through extensive marshes until it reaches the Charles River Basin at the lower dam at Watertown. The river flows successively past the villages of Milford, West Medway, Medway, South Natick, Charles River Village and Dedham, and the cities of Waltham, Watertown and Newton. Its total length along the channel is about 65 miles, although the distance in a straight line from its source to the lower dam at Watertown is only about 20 miles.

The drainage area at the lower dam in Watertown covers a total of about 270 square miles, but the yield of the watershed is affected by the rights granted in 1798 to the proprietors of mills on Mother Brook in Dedham to divert one-third of the flow of the Charles River at a point in East Dedham through a canal to Mother Brook, and thence to the Neponset River. The watershed of the Charles River above this point of diversion is 198.6 square miles, and hence a flow equivalent to that from 66.2 square miles is diverted into Mother Brook. This leaves the effective watershed at the lower dam in Watertown at about 204 square miles.

In the report of the Joint Board upon the Improvement of the Charles River to the Legislature in 1894, Frederic P. Stearns, engineer, makes the statement that the ordinary summer flow of the stream at the Watertown Dam may be reckoned at 62 cubic feet per second, and the minimum flow is not more than half of this amount; also that the average daily flow throughout a series of years, upon the assumption that one-third of the water is diverted at Mother Brook, is about 340 cubic feet per second, and the maximum flow of the stream during the highest known freshet, namely, that of February, 1886, was about 4,900 cubic feet per second at the dam of the Boston Manufacturing Company at Waltham, and by estimation 5,200 cubic feet per second at the Watertown Dam. Apparently these statements are correct for the present flow, as

no diversions or changes in drainage area have taken place since then.

The drainage basin is from 7 to 10 miles wide in the lower portion, narrows to 5 miles in the central part, and broadens to a maximum of 15 miles toward the headwaters. The country thus included is one of only moderate slopes. Along the divide the higher summits seldom rise more than 300 or 400 feet above mean sea level, and none reach 600 feet. As a natural result the lower main river is rather slow to respond to heavy rains. On the other hand, the natural flow seems to be fairly well sustained in the upper part of the river during the dry season, although it receives but small aid from artificial reservoirs.

Within the basin there are 16 ponds of more than 20 acres each in area. Only 4 of these contain more than 100 acres each.

In 1910 a dam was completed across the Charles River near the site of the old Craigie bridge, forming the Charles River Basin. The water level in this basin is kept at a constant elevation of about 8 feet above mean sea level. In this construction provision was made for diverting the polluted flow of Stony Brook and Muddy River tributaries from the Fenways outlet by means of marginal conduits parallel to the stream, along the Beacon Street side of the river, and emptying into the river at a point below the dam. Before this dam was constructed the effect of the tide was felt up as far as the lower dam in Watertown, about $8\frac{1}{2}$ miles above the Charles River Dam.

The following table shows the population of the cities and towns that are largely drained by the Charles River: —

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Bellingham, ...	1,953	Millis, ...	1,462
Belmont, ...	8,081	Natick, ...	11,119
Boston, West Roxbury district, .	21,442	Needham, ...	6,542
Dedham, ...	11,043	Newton, ...	43,113
Dover, ...	999	Norfolk, ...	1,268
Franklin, ...	6,440	Sherborn, ...	1,696
Holliston, ...	2,788	Waltham, ...	30,154
Hopkinton, ...	2,475	Watertown, ...	16,515
Lincoln, ...	1,310	Wellesley, ...	6,439
Medfield, ...	3,643	Weston, ...	2,342
Medway, ...	2,846	Westwood, ...	1,443
Milford, ...	13,684	Wrentham, ...	2,414

The following is a list of the principal tributaries of the Charles River, with their drainage areas:—

BRANCH.	Drainage Area (Square Miles).
Mine Brook, ...	15.5
Hopping Brook, ...	11.0
Mill Brook, ...	15.5
Stop River, ...	19.0
Boggestowe Brook, ...	10.5
Beaver Brook, ...	10.5
Stony Brook, ...	23.6

Industrial Development of the Charles River.

Table No. XLIV., on page 249, gives a list of the water powers on the main portion of the river. The total fall obtained between the Charles River Basin and South Natick amounts to 91 feet, which is developed at eleven dams, a number of which are only 6 feet in height and are not at present used for developing water power.

Starting at Watertown and going up-stream, the principal industrial plants in which the water of the Charles River is used for power or other purposes are as follows:—

Union Bag and Paper Company, part owners with the Metropolitan Park Commission and the Waltham Savings Bank of the lower dam in Watertown, utilizes the water for washing purposes only. There is an available head of about 5.8 feet. The watershed above this dam covers an area of about 269.88 square miles, the flow from 66.2 square miles of which is diverted through Mother Brook into the Neponset River, leaving a watershed of 203.68 square miles available at this point.

Lewandos, a laundering, cleansing and dyeing establishment located in Watertown, uses water for those purposes but not for power.

The Ætna Woolen Mills, located just below Bemis, and the oldest mill in this section of the country, own and control a dam with a fall of about 4.8 feet, using the water for washing purposes only.

The Waltham Bleachery and Dye Works own and control a dam just east of the railroad crossing of the Fitchburg Division of the Boston & Maine Railroad, using the water for dyeing and bleaching, but not for power. The elevation of the crest of this dam is 26.0 feet above mean low water in Boston Harbor; there are 5 inches of flashboards permanently attached to the dam, and the water surface floods back to the toe of the next dam above. The fall at this dam is about 4.4 feet.

The Boston Manufacturing Company, located at Moody Street in Waltham, owns and controls a dam with a fall of 12.8 feet, with the top of the dam at an elevation of 37.85 feet above mean low water in Boston Harbor. There are three rows of 10-inch flashboards on this dam, the lower one of which is permanently attached to the structure of the dam, the elevation of the top being about 40.35. The water surface floods back to Riverside. Water is used for power, dyeing, bleaching and finishing in the manufacture of cotton goods. The installation for water power consists of three 110-horsepower wheels of the Holyoke type. Considerable trouble is found with the water for boiler use, due to a deposit injurious to the tubes.

The plants of the Newton & Watertown Gas Light Company and the Edison Electric Illuminating Company are located below the above dam but do not use river water.

The Waltham Watch Company, employing about 4,000

hands, and the large Waltham Laundry, are located above the dam of the Boston Manufacturing Company, but use the water for boilers only, discharging condenser and wash water back into the river.

At Newton Lower Falls there are three dams. At the lower dam there were formerly two mills, — the R. T. Sullivan Company, making shoddies and wool extracts, and the Wiswall Paper Mill. This latter mill was bought by the Metropolitan Park Commission and torn down, and the commission holds a one-half interest in the dam. The available head is about 6.0 feet, and the installation in the R. T. Sullivan Company mill consists of one Hunt, one Huston and one Hercules wheel, with an average power output of about 50 horsepower, or about 75 horsepower during periods of high water. About 75 to 100 hands are employed at this mill.

The middle dam at Newton Lower Falls is controlled by the Wellesley Knitting Mills, with a fall of about 6.0 feet. This mill uses steam power almost entirely, as it receives but a portion of the flow of the stream, the balance being taken from the upper dam and discharged below the middle one.

The upper dam at Newton Lower Falls is controlled by C. F. Crehore & Sons, manufacturers of press board paper, employing less than 25 hands. By combining the fall at the two upper dams the head here is about 16.0 feet, and the mill is equipped with four Lake wheels with a total rating of 125 horsepower. Water is also used for washing. There is practically no rise in the water surface from this dam up-stream to the dam at Newton Upper Falls. The superintendent of this mill states that the available water power falls very low in summer, and that additional storage on the river above would greatly benefit all of the mills on the river. W. S. Cordingly & Sons operate a shoddy mill just below the Crehore mill, use the same dam, and depend for their water-power development upon Crehore's use. From 75 to 100 hands are employed here, and the mill is equipped with one 100-horsepower and one 30-horsepower Victor wheel. The superintendent of this mill states that during low flow periods in the summer time there appears to be a largely increased flow at the upper dam after about 10 o'clock P.M. Water is also used at the Cordingly Mill for dyeing and washing.

At Newton Upper Falls there are two dams. The fall at the lower, known as the Horseshoe Dam, is small and is not in use. At the upper is the large mill of William Ryle & Co., known as the Newton Mills, manufacturers of spun silk yarns, and employing about 250 hands when full. The dam has an effective head of about 15.0 feet, and the mill is equipped with one 23-inch and one 48-inch Holyoke wheel, with a total rating of 150 horsepower. Water is also used for bleaching, dyeing and washing. In periods of low flow an auxiliary steam engine is used, which is coupled to the wheel in periods of high flow.

At Charles River Village there was formerly an old paper mill which was recently taken over by the Needham Tire Company, operating day and night with about 120 hands in the manufacture of automobile tires. There is a small mill pond and a dam with an effective head of about 14.0 feet. The mill is equipped with two 46-inch Samson wheels, rated at 110 horsepower each. The superintendent states that both wheels were run continuously during the year 1915, probably due in a large measure to the heavy rains of July, 1915. This dam is located above the canal leading into Mother Brook at Dedham, and therefore can utilize the entire flow of the river.

The only remaining dam of any importance on the Charles River is that now owned and controlled by the Eliot Mills, Inc., at South Natick, and formerly owned by the Boston Bedding Company. The dam is about 8.0 feet in height, with a canal leading to the mill where the available head is about 12.0 feet. Cotton batting and felts are manufactured, the mill employing about 30 hands and being equipped with two water wheels, the type, size and rated capacity of which could not be obtained.

Legislation affecting the Charles River.

Most of the important legislation affecting the Charles River has been with reference to the creation of the Charles River Basin in the tidal section of the river below the lower dam at Watertown. No analysis of the Charles River Basin legislation is contained in this report.

The proprietors of mills on the Charles River were incorporated under an act passed in 1798, in which year also the proprietors of mills on Mother Brook and the Neponset River

were incorporated. These mills were all interested in the diversion of water from the Charles River into the Neponset River through Mother Brook in Dedham. This diversion was first made through an old canal which was excavated to connect the two streams as early as 1639. In 1831 an agreement was finally reached between the mills at interest whereby it was decided that the mill owners on Mother Brook and the Neponset River should have the right to divert one-third of the flow of the Charles River at the point of entrance of the canal at East Dedham, the other two-thirds to be allowed to pass on down to the mill owners on the Charles River. This agreement was recorded in the court at Dedham.

In chapter 161 of the Acts of 1900 provision was made for the appointment of a commissioner whose duties since that time have been to supervise the control of the flow of the Charles River at East Dedham so that the above proportionate division should be properly made, and to keep the sills and dams regulating that flow in good condition. Careful records of flow have been kept since that time. Mother Brook was formerly known as Mill Brook, and so appears in the act of 1798. The watershed above the canal entrance at East Dedham is about 198.6 square miles, the flow from 66.2 square miles of which is diverted through Mother Brook.

Storage.

Table No. XLV., on pages 250 and 251, gives the principal lakes and ponds with various details.

The low season flow of the Charles River at Waltham falls as low as between 10 and 20 second-feet. This low season flow is so small that only a limited amount of water power can be developed from the stream during the dry months of the year. However, as far as could be learned there are no instances where industries have suffered from a lack of sufficient water for boiler, condensing and manufacturing purposes. As compared with conditions on the Quequechan River at Fall River the number of mills on the Charles is so small and the drainage area so large that the supply of water is very much greater.

It is understood that the various mills all look with favor upon increased storage capacity on the river and a greater dry-

season flow, but as to whether the need for this is so great that they would be willing to contribute substantially towards its cost is very doubtful.

Following is a description of possible storage sites. Consideration of storage sites below South Natick may be omitted, as they would not be feasible when the cost per million cubic feet of storage provided and the total volume of storage obtainable are taken into account. It is probable that density of population and inadequate drainage area would eliminate the watersheds of Beaver and Clematis brooks. The watersheds of Stony Brook and its feeder, Hobbs Brook, are utilized for public water supplies. The areas between Stony Brook and South Natick appear to offer no satisfactory storage sites.

In the 1895 report of the State Board of Health on the metropolitan water supply, among other possibilities the construction of a dam above South Natick was suggested. This was first proposed in 1874. A dam 15 feet high would flow an area of 6.12 square miles to an average depth of 9.08 feet, with a storage capacity of 9,000,000 gallons, while a dam 21 feet high would flow an area of 7.04 square miles to an average depth of 12 feet, with a storage capacity of 18,000,000,000 gallons. The watershed above this point would be 156.3 square miles.

A study of the sheets of the United States Topographical Survey shows that such a basin would consist of several very long arms apparently extending into the towns of Sherborn, Medfield, Dover, Millis and Norfolk, and it is evident that such a storage reservoir is not feasible to-day, largely on account of the general development of that section of the State since 1874. The cost of land damages would undoubtedly be prohibitive.

The watersheds of Hopping Brook in Holliston, Milford and Medway, and of the brook running through Whitings Pond in Wrentham and City Mills in Norfolk offer no suitable reservoir sites.

By the construction of a dam probably 30 feet in height and several dikes on Mine Brook at a point southeast of Caryville in the town of Bellingham, and flowing to the 200 contour as shown on the United States topographical sheet, a reservoir can be formed covering probably 1.25 square miles and containing

possibly 325,000,000 cubic feet. Such a basin would flow back nearly to Unionville in the town of Franklin.

A dam built on Stop River at a point just southeast of Highland Lake in the town of Norfolk would flood an area of about 1.25 square miles, and store probably as much as 300,000,000 cubic feet.

The basins on both Mine Brook and Stop River would involve considerable important highway relocation or change in elevation.

A dam on the Charles River at a point about 1 mile south of South Sherborn would form a basin covering a large area flooding back into the towns of Millis and Medfield, but would flow a wide extent of apparently valuable farming land and involve many highway and railroad changes.

The best location found for a storage reservoir above South Natick, so far as the present investigation indicates, is in the town of Millis, where, by the construction of a dam about 300 feet long and 30 feet high across Boggastowe Brook on Orchard Street, a storage basin could apparently be formed covering a water surface of about 2.5 square miles, or 1,600 acres, with an average depth of probably as much as 10 feet, a storage capacity approximating 700,000,000 cubic feet, and with a drainage area of at least 22 square miles. The southern end of this basin would be just east of the town of Medway, where a dike would be advisable to cut off what otherwise would be a long arm of the basin running back to the northeast toward Medfield Junction. A very large part of this basin would flood a swampy area across the southern part of which the Woonsocket Division of the New York, New Haven & Hartford Railroad passes on an embankment which apparently would not require any change. In the northern section of this basin is a rising knoll of land on which the farm of Lemuel Clark is located. This property, with its farm land below along the brook, would have to be acquired, and the knoll would form an island in the reservoir. Some highway changes would be involved. There is a dam site very favorable for economical and safe construction just above the highway crossing, making changes in Orchard Street unnecessary.

The storage thus formed on Boggastowe Brook, amounting to approximately 700,000,000 cubic feet, or about 5,250,000,000 gallons, would be filled at the beginning of each dry period from the drainage area of about 22 square miles, thereby furnishing a supply of 70,000,000 gallons per day over a period of seventy-five days without any inflow into the basin. Deducting 25,000,000 gallons per day for the use of the cities and towns below for purposes of public water supplies, there would still remain 45,000,000 gallons per day, or a flow at the rate of about 70 second-feet.

TABLE XLIV. — *Water Power on the Charles River in Massachusetts.*

[S. indicates steam.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Auxiliary Horsepower.	Remarks.
1	Union Bag and Paper Company, ¹	Watertown, . . .	Paper, . . .	24	370.02	5.8	-	-	No water power used.
2	Atlas Woolen Mills, . . .	Bensla, . . .	Woolens, . . .	9	203.0	4.8	-	-	No water power used.
3	Waltham Bleachery and Dye Works,	Waltham, . . .	Textiles, . . .	-	250.0	4.4	-	-	No water power used.
4	Boston Manufacturing Company, .	Waltham, . . .	Cotton goods, .	9	248.0	13.0	220	-	-
5	R. T. Sullivan Company, ² . . .	Newton Lower Falls, .	Shoddy, . . .	9	214.0	6.0	75	S.	-
6	Webbsley Knitting Mills, . . .	Newton Lower Falls, .	Hosiery, . . .	9	214.0	6.0	-	-	No water power used.
7	C. F. Crebore & Sons, . . .	Newton Lower Falls, .	Press Board, . .	-	213.5	16.0 ⁴	125	-	Water used for washing also.
	W. S. Cordingley & Sons, . . .	Newton Lower Falls, .	Shoddy, . . .	9	213.5	16.0 ⁴	120	-	Water used for washing also.
8	Not known, . . .	Newton Upper Falls, .	- . . .	-	212.0	Low	-	-	Horseshoe Dam, not used.
9	Newton Mills, . . .	Newton Upper Falls, .	Silk yarns, . . .	9	211.5	15.0	150	-	Water also used for bleaching, dyeing and washing.
10	Needham Tire Company, . . .	Charles River Village, .	Automobile tires, .	24	180.0	14.0	220	-	-
11	Eliot Mills, Inc., . . .	South Natick, . . .	Cotton goods, . .	9	154.0	12.0	200 ⁵	-	-
	Total, . . .	- . . .	- . . .	-	-	-	1,220	-	-

¹ Part owners with Metropolitan Park Commission and Waltham Savings Bank.² Flow from 66.2 square miles of this area diverted to Mother Brook, and affects powers Nos. 1 to 9, inclusive.³ Part owners with Metropolitan Park Commission.

Drainage area at Charles River Dam, 200 square miles.

Twelve small privileges above No. 11.

⁴ Fall includes that at No. 6.⁵ Power estimated.

TABLE XLV. — *Principal Lakes and Ponds on the Charles River in Massachusetts.*
 [Except where otherwise noted, areas of ponds are obtained from the original plane table sheets of State topographical map. Scale, 1:50,000.]

No.	NAME OF POND.	Location.	Drainage Area (Square Miles).	Area of Pond (Acres).	Remarks.
1	Echo Lake,	Hopkinton, ...	2.35	73	-
2	Cedar Swamp Pond,	Milford, ...	10.00	95	-
3	Factory Pond, ...	Hopedale and Bellingham, ...	14.40	28 ¹	-
4	Lake Winthrop,	Holliston, ...	2.20	83	-
5	Talbot Pond, ...	East Holliston, ...	2.50	26	-
6	Factory Pond, ...	East Holliston, ...	6.30	16	-
7	Beaver Pond, ...	Bellingham, ...	1.90	38	-
8	Pond west of Bellingham,	Bellingham, ...	1.40	24	-
9	Pond south of North Bellingham,	North Bellingham, ...	6.50	21	-
10	Beaver Pond, ...	Franklin, ...	8.10	36	-
11	Unionville Pond,	Franklin, ...	9.35	31	-
12	Uncas Pond,	Franklin, ...	.90	27	-
13	Archers Pond,	Wrentham, ...	6.30	83	-
14	Lake Pearl,	Wrentham, ...	11.60	273	Or Whitney's Pond.
15	Pond northeast part of Franklin,	Franklin, ...	1.10	25	-
16	Reservoir Marsh Pond,	Wrentham and Norfolk, ...	1.40	63 ¹	-

17	Highland Lake,	.	.	.	.	.	.	.	11.05	14	-	-	-
18	Kingsbury Pond,	.	.	.	.	.	.	.	.15	20	-	-	-
19	Populatic Pond,	.	.	.	.	.	.	.	68.70	48 ¹	-	-	-
20	Sabrina Lake,	.	.	.	.	.	.	.	.50	23	-	-	-
21	Needham Reservoir,	.	.	.	.	.	.	.	2.00	15	-	-	-
22	Morses Pond,	.	.	.	.	.	.	.	6.00	110 ¹	-	-	-
23	Waban Lake,	.	.	.	.	.	.	.	6.90	126	-	-	-
24	Nonesuch Pond,	.	.	.	.	.	.	.	.55	40 ¹	-	-	-
25	Hammonds Pond,	.	.	.	.	.	.	.	.80	17	-	-	-
26	Crystal Lake,	.	.	.	.	.	.	.	.50	41	-	-	-
27	Sandy Pond,	.	.	.	.	.	.	.	.80	154 ¹	-	-	-
28	Beaver Pond,	.	.	.	.	.	.	.	.90	112	-	-	-
29	Hardys Pond,	.	.	.	.	.	.	.	.50	47	-	-	-
30	Farm Pond,	.	.	.	.	.	.	.	.60	124 ¹	-	-	-
31	Hobbs Brook Reservoir,	.	.	.	.	.	.	.	6.40	559 ¹	-	-	-
32	Stony Brook Basin,	.	.	.	.	.	.	.	23.60	73 ¹	-	-	-
33	Weston Reservoir,	.	.	.	.	.	.	.	.90	60 ¹	-	-	-
										Or Wiswall's Pond.			
										Includes upper and lower basin, Cambridge water supply.			
										Cambridge water supply.			
										Metropolitan water supply.			

¹ Areas obtained from large scale plan or reliable local sources.

NEPONSET RIVER.

The Neponset River has its source in the Neponset Reservoir in the village of Foxborough. From this reservoir it flows in a northerly direction through the towns of Foxborough and Walpole to Walpole Center, and thence in a generally northeasterly direction through the towns of Walpole, Norwood, Canton, Milton and Dedham, and the Hyde Park and Dorchester districts of the city of Boston, discharging into tidal water in Dorchester Bay just below Adams Street at the chocolate mills of Walter Baker & Co. Its total length is about 24 miles.

In its upper course through a distance of about 10 miles, from the Neponset Reservoir down to a point about one-half mile below Pleasant Street in Norwood, the river has an average fall of about 22.7 feet per mile. The elevation of the bed at the latter point is about 48 feet above mean low water. The fall in this part of the river is largely taken up by low dams which pond water for manufacturing purposes.

From a point one-half mile below Pleasant Street in Norwood down to the Tileston & Hollingsworth Dam near River Street in Hyde Park, a distance of about 12 miles by the new channel dredged under the supervision of the State Department of Health in 1913-15, the total fall of the river is about 10 feet, or an average fall of about 0.83 foot per mile. In this section of the river the channel passes through an extensive area of practically level land known as the Fowl or Great Meadows, which cover about 3,662 acres located in the towns of Norwood, Sharon, Canton, Westwood, Dedham and Milton, and the Hyde Park district of the city of Boston. From the top of the Tileston & Hollingsworth Dam to tidewater is a distance of about 2.7 miles, with a total fall of about 38 feet to mean low water, which is taken up by five privileges. Tidewater extends up as far as the lower mills in Milton, and the river continues from there as an estuary for about 4 miles, until it discharges into Dorchester Bay.

Mother Brook enters at Hyde Park below the lower end of the Fowl Meadows, and through it one-third of the flow of the Charles River above East Dedham is diverted to the Neponset River. The Canton branch, which with its tributaries drains

Canton and Sharon, joins the river near the upper end of the Fowl Meadows, and contributes a drainage area of 31 square miles.

The drainage area of the main river is 2.7 square miles at the Neponset Reservoir, 26 square miles at the upper end of the meadows in Norwood, and about 95 square miles just above the entrance of Mother Brook. The drainage area is increased by 68 square miles by Mother Brook, which includes one-third of the area of the Charles River above the point of diversion. At the mouth of the river in Milton Lower Mills the watershed of the Neponset proper amounts to 114 square miles, or 180 square miles after adding the area from the Charles River.

The basin is largely in Norfolk County, and drains part or all of the area of the following cities and towns: —

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Boston:		Milton, ...	8,600
Ward 24, Dorchester, . .	22,615	Norwood, ...	10,977
Ward 26, Hyde Park, . .	18,381	Walpole, ...	5,490
Canton, ...	5,623	Sharon, ...	2,468
Dedham, ...	11,043	Stoughton, ...	6,982
Foxborough, ...	3,755	Westwood, ...	1,448

The drainage area and slope of the Neponset River are too small to make it an important water-power stream. Table No. XLVI., on pages 261 and 262, shows the privileges on the main river and the more important tributaries. The form of the table is the same as that adopted for the water-power streams, which has been retained for the sake of uniformity. As will be seen, the more important privileges are those located below the Fowl Meadows, between the Tileston & Hollingsworth privilege and tidewater, but at none of these is a head of over 10 feet obtained. The principal use of the stream is for manufacturing purposes in Hyde Park, Milton, Norwood, Canton and Sharon. Due to the number and the character of the industries discharging waste into the river it is badly polluted.

Table No. XLVII., on page 263, gives the principal manu-

facturing plants which discharge waste into this river and the method of treatment of wastes. In the summer at the time of low flow the pollution is so bad that even though Warren filters are used at the Tileston & Hollingsworth plant, they are unable to handle the polluted water, and recourse is had to the water of the metropolitan system for manufacturing uses.

The present supply for manufacturing purposes is sufficient at the present time, the greatest difficulty being with the troubles caused by pollution.

Table No. XLVIII., on pages 264 and 265 shows the principal lakes and ponds on the watershed and their use. The total water surface area, including the river, amounts to about 3.024 square miles, or 2.65 per cent. of the total watershed, not including the area contributed by the Charles River through Mother Brook.

The Neponset Valley has been the subject of much legislation and of many official investigations. The acts have been primarily concerned with the conditions arising out of the diversion of the Charles through Mother Brook, the pollution of the river and the drainage of the Fowl Meadows. The various acts and investigations affecting the watershed are described below.

Some of the towns located in this valley were among the first to be settled in the eastern part of Massachusetts, notably the town of Dedham, which was settled in the year 1636. In the year 1639 a town ordinance was passed in Dedham directing the digging of a ditch to connect the Charles River with the Neponset River, with the object of furnishing more water in Mother Brook for the use of a public grist mill, thus starting the first industrial development in the Neponset Valley.

The proprietors of mills on Mother Brook and the Neponset River were incorporated under an act passed by the Massachusetts Legislature in 1798, in which year also the proprietors of mills on the Charles River were incorporated. These two incorporations covered the original parties who were interested in the diversion of water from the Charles River into the Neponset River through Mother Brook, the diversion being made through the old channel started in 1639. As the growth of factories advanced on Mother Brook, the question of the proportionate amounts of water to be used by the two corpora-

tions of mill proprietors became a subject of long dispute and disagreement, and it was not until the year 1831 that a final agreement, not decreed by any court, but made between the parties at interest, was reached, whereby it was decided that the mill owners on Mother Brook should have the right to divert one-third of the flow of the Charles River at the point of entrance of the canal at East Dedham, the other two-thirds of the flow to go to the mill proprietors on the Charles River. This agreement was recorded in the court at Dedham, and has been in operation throughout the entire period since 1831.

In chapter 161 of the Acts of 1900, entitled "An Act to provide for protecting the flow and supply of water from the Charles River into and through Mother Brook at the Neponset River," provision was made for the appointment of a commissioner by the proprietors of the mills on Mother Brook and Neponset River, whose duties should be to supervise the control of the flow of the Charles River so that the above proportionate division of the flow should be properly made, and to keep the sills and dams regulating this flow in good condition. Under this act Mr. Erastus Worthington of Dedham was appointed commissioner, and is serving in that capacity to-day. Careful records have been kept since that time of the flow in the Charles River at that point and the flow through Mother Brook into the Neponset River. Mother Brook was formerly known as Mill Brook, and so appears in the above act.

On March 3, 1798, there was passed "An Act to incorporate certain proprietors of meadow lands lying on each side of Neponset River, in the towns of Dedham, Milton and Canton, and for drawing off the stagnant waters and for better improving said meadow lands." An act in addition to the above act was passed on March 11, 1802, defining anew the exact lands to be included. These acts provided for the draining and improving of the meadow lands at the common expense of the proprietors.

On March 6, 1802, there was passed "An Act to incorporate certain proprietors of meadow lands lying on Pequit Brook, within the town of Canton, for the purpose of flowing and draining off the stagnant waters and for the better improving of said lands." Pequit Brook was a part of what is to-day

known as the Canton River, or the East Branch of the Neponset River.

Certain improvements were made by the proprietors of these meadow lands at different times, but nothing on a large scale was attempted either for the draining of the meadow lands or the conserving of the flow of the stream. In the early years of the nineteenth century many of the mill privileges on the upper Neponset River and on the East Branch or Canton River were established and the original dams constructed. No united effort to conserve the flow of the river was made until 1845. By chapter 48 of the Acts of the year 1845, entitled "An Act to incorporate the Neponset Reservoir Company," rights were given to certain mill owners on the Neponset River, running down into the Hyde Park district, to construct and maintain a reservoir by the erection of a dam across the Neponset River in the town of Foxborough. This legislation resulted in the formation of the Neponset Reservoir, which is considered to be the source of the Neponset River. As noted in Table XLVIII. this reservoir covers a large area, but has a relatively small storage capacity. It has, however, been of great benefit in equalizing the flow in the river for the use of the comparatively small water-power developments on the stream, as well as for manufacturing uses.

By chapter 321 of the Acts of 1853 the Neponset Reservoir Company was given the right to increase its capital stock. That company to-day is composed of Charles S. Bird of Bird & Son, paper manufacturers at East Walpole; the Hollingsworth & Vose Company, paper manufacturers at East Walpole; the Tileston & Hollingsworth Company, paper manufacturers at River Street in Hyde Park; Walter Baker & Co., chocolate mills at Dorchester at tidewater; and Isaac N. Lewis of Walpole. The maintenance and handling of the flashboards at the outlet of the Neponset Reservoir is attended to by Bird & Son, the expenses being divided annually between the members of the company. All intervening and lower mill privileges on the Neponset River have been able to utilize the full benefit of this storage and regulation.

Under chapter 75 of the Acts of the year 1876, "An Act to incorporate the owners of meadow lands lying in the Nepon-

set River," the old original owners were reorganized into the Neponset Meadow Company, with powers under the above act to drain and improve the meadows and to remove obstructions from the river. Considerable work was done on a small scale, resulting in a somewhat better flow and localized improvement. Even at that time, however, the dam of the Tileston & Hollingsworth Paper Company in Hyde Park caused the back water to flood the meadows above the dam, especially during heavy rains in the summer and early fall. It was not, however, until several years later that the manufacturing wastes discharged into the river from various industries made their injurious effect felt upon the cultivation of the meadow lands.

The official investigations of the Neponset Valley began as early as the year 1875, and were largely brought about by the activities of the members of the Neponset Meadow Company, whose direct interest in the reclaiming and cultivation of the meadow lands led them to seek every improvement possible, together with the prevention of further pollution and the remedying of the conditions of back water from the Tileston & Hollingsworth Dam with the resulting flooding of the meadows.

Under chapter 192 of the Acts of the year 1875 the State Board of Health was directed to investigate and report on the drainage, sewerage and protection of public health in the valleys of certain rivers in eastern Massachusetts, among which was the Neponset River.

Again, under chapter 63 of the Resolves of the year 1884, the Massachusetts Drainage Commission was established, which commission made a thorough investigation of the Neponset valley in 1885, with a report on the same in 1886. Under chapter 86 of the Resolves of the year 1886 all of the plans and information collected by the Massachusetts Drainage Commission were turned over to the State Board of Health. Under chapter 274 of the Acts of the year 1886, covering the protection of the purity of inland waters, the Neponset River came under the control of the State Board of Health in that respect. In the year 1890 the river and valley were thoroughly examined by the State Board of Health.

Under chapter 83 of the Resolves of 1895 the State Board of Health was finally directed to investigate the Neponset Valley

and report a plan for improving the Neponset River in such a way as to prevent flooding of the meadows lying above Paul's Bridge in the town of Milton. A report on this matter was given to the Legislature in 1897, with two recommendations, — first, that pollution of the stream by sewage and manufacturing wastes which had not been satisfactorily purified should be prevented by additional legislation; and second, that the river channel should be rectified, deepened and enlarged by dredging, together with the permanent removal of the flashboards on the dam at the Tileston & Hollingsworth Paper Mill in Hyde Park for the purpose of preventing the flooding of the meadows above Paul's Bridge during the times of high flows in the late spring and summer. No action on these recommendations was taken until the year 1902, when the Legislature passed chapter 541 of the Acts of 1902, providing for the prevention of the pollution of the river, which act was amended by chapter 360 of the Acts of the year 1906. It is under this latter act to-day that efforts are being made to reduce the amount of polluting matter now allowed to enter the stream from the various manufacturing plants located along its banks, many of which have already installed systems of treatment and filtration.

Under chapter 406 of the Acts of the year 1895, chapters 80 and 502 of the Acts of the year 1897, chapter 4 of the Resolves of 1898, and chapter 424 of the Acts of 1899, adequate provision was made for a system of sewage disposal for the lower Neponset River valley, and the towns of Dedham and Milton and the Hyde Park district of the city of Boston are now connected with the metropolitan sewerage system which discharges into tidewater at Nut Island.

Under chapter 655 of the Acts of the year 1911, and acts in addition thereto in 1913, 1914 and 1915, the State Board of Health was directed to carry out the second recommendation contained in its report of 1897, by dredging a new channel for the Neponset River through certain portions of its course. Under that act, in the years 1913, 1914 and 1915, the old channel of the river was enlarged, deepened and rectified over a distance of about $12\frac{1}{2}$ miles from the dam of the Tileston & Hollingsworth Paper Mill at River Street in Hyde Park to a point at the upper end of the Great Meadows, about 1 mile

below Pleasant Street, Norwood. This new channel was designed for a maximum flow of at least 4 second-feet per square mile of watershed, but by reason of excess material dredged outside of the lines and grades established for the new channel, and as verified by stream measurements since the completion of dredging, the new channel will carry off a flow at a considerably higher rate without flooding the meadows.

The sum of \$150,000 was appropriated by the initial act of 1911, to be spent during the years 1911, 1912 and 1913. To this \$35,000 was added by the act of 1913; \$10,000 by the act of 1914; and \$8,000 by the act of 1915. In reporting to the Legislature of 1916 the State Department of Health also recommended a further expenditure of about \$60,000 to provide for side ditches and other improvements.¹ The channel through the meadows has considerably lowered the level of the water in the river, and consequently the ground water level in the meadows adjoining, but the report of the State Department of Health states that the additional drainage ditches will be required before the land at a distance from the river can be properly drained. This was referred to the next General Court. By chapter 146 of the Resolves of 1916 an additional \$3,000 was appropriated for the purpose of carrying out the provisions of chapter 655 of the Acts of 1911, and for investigations as to the control and regulation of the height of water at the Mattapan Mills Dam of the Tileston & Hollingsworth Company. Resolve No. 1032, submitted to the Legislature of 1916, asked for the sum of \$2,000, to be expended by the State Department of Health for the investigation of the feasibility and probable cost of draining and improving the low and marsh land along the lower reaches of the Neponset River and the shores of Quincy Bay, to the end that the nuisance and danger of mosquitoes be evaded and the public health conserved. This had no relation to the new channel through the Fowl Meadows.

As to the question of the necessity or desirability of new storage reservoirs on the Neponset watershed it can hardly be said that there is any call for them at the present time. The fall on the river is entirely too small to warrant the building of reservoirs for the benefit of water powers. At the present time

¹ 1916, H. 1780.

the supply for manufacturing purposes is sufficient, and the most urgent problem is the prevention of pollution rather than increased storage. It is conceivable that a time may come when the valley will have so grown up as to make a better sustained summer flow necessary, and it is not impossible that water will some day be needed for irrigating the meadows in case they are brought under cultivation. There are eight sites on which the construction of reservoirs would appear possible from the Geological Survey map.

TABLE XLVI. — *Water Power on the Neponset River in Massachusetts.*

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet Per Cent. Efficiency.	Area of Pond (Acres).	Remarks.
<i>Neponset River.</i>										
1	Walter Baker & Co.,	Dorchester,	Chocolate,	9	180.0	3.0	60 ¹	-	Small	Head varies from 0 to 6 feet with tide.
2	Walter Baker & Co.,	Dorchester,	Chocolate,	9	180.0	8.0	175 ¹	1.34	Small	-
3	Walter Baker & Co.,	Dorchester,	Chocolate,	9	170.0	8.0	200 ¹	1.03	Small	-
4	Wm. B. Curtis & Sons,	Mattapan,	Lumber,	9	167.0	6.6	180 ¹	1.03	Small	-
5	Tilston & Hollingsworth,	Hyde Park,	Paper,	24	165.0	8.0	100 ¹	.84	- ²	-
6	Hollingsworth & Vose,	East Walpole,	Paper,	24	26.0	8.0	-	-	6	-
7	Bird & Son,	East Walpole,	Paper,	24	26.0	14.0	-	-	29	-
8	Geo. A. Plympton,	East Walpole,	-	-	25.0	9.0	-	-	16	Used for storage by Bird & Son.
9	Luxmoor Company,	Walpole Center,	Felt,	-	21.0	10.0	25 ¹	1.31	6	-
10	Lewis Manufacturing Company,	Walpole Center,	Cotton goods,	9	12.0	6.0	-	-	7	-
11	Standard Woven Fabric Company,	Walpole Center,	Rubber goods,	9	12.0	8.0	-	-	9	-
12	Standard Woven Fabric Company,	Walpole Center,	Rubber goods,	9	12.0	10.0	-	-	3	-
13	Standard Woven Fabric Company,	Walpole Center,	Rubber goods,	9	11.0	3.0	-	-	2	-
14	Bird & Son,	South Walpole,	-	-	4.0	6.0	15 ¹	6.90	4	Storage.

¹ Power estimated.

² This dam controls long flat stretch of river extending back into Fowl Meadows.

TABLE XLVI. — *Water Power on the Neponset River in Massachusetts — Concluded.*

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile 80 Per Cent. Efficiency.	Area of Pond (Acres).	Remarks.
15	Norfolk & Bristol Street Railway Company,	South Walpole,	-	-	4.0	5.0	-	-	-	-
16	Bird & Son, ...	South Walpole,	-	-	3.8	9.0	-	-	2	Storage.
17	Union Light and Power Company, ...	Foxborough,	Electricity,	-	2.8	6.0	-	-	-	-
18	<i>Moker Brook.</i> Manchaug Company, ...	Readville,	Cotton goods,	9	68.0	7.0	40 ¹	.98	23	-
19	Cochrane Manufacturing Company, ...	East Dedham,	Cotton goods,	9	67.0	19.0	-	-	-	-
20	Cochrane Manufacturing Company, ...	East Dedham,	Cotton goods,	9	67.0	-	-	-	-	-
21	Dedham Finishing Company, ...	East Dedham,	-	-	66.0	5.0	-	-	-	-
22	Hodges Finishing Company, ...	East Dedham,	-	-	66.0	10.0	-	-	-	-
23	<i>East Branch or Canton River.</i> Neponset Woolen Mills, ...	Canton Junction,	Woolens,	9	20.0	9.0	25 ¹	1.02	13	-
24	Plymouth Rubber Company, ...	Canton,	Rubber goods,	-	28.0	8.0	100	9.25	-	-
25	Plymouth Rubber Company, ...	Canton,	Rubber goods,	-	28.0	8.0	50 ¹	2.46	-	-
26	Plymouth Rubber Company, ...	Canton,	Rubber goods,	-	28.0	8.0	-	-	26	-
27	Ames Shovel and Tool Company, ...	Canton,	-	-	11.0	9.0	25 ¹	2.78	20	-
	Total, ...	-	-	-	-	-	1,085 ¹	-	-	-

¹ Power estimated.

TABLE XLVII. — *Principal Manufacturing Plants discharging Wastes into the Neponset River and its Branches.*

NAME.	Output.	Treatment of Wastes.	Use of Water.
<i>Walpole.</i>			
White, Son Company, .	Leather goods, . .	Very crude, . .	Small.
Standard Woven Fabric Company.	Rubber goods, . .	None, . . .	Considerable.
S. Gray & Co., . .	Dyeing and finishing textiles.	Crude tank and filters.	50,000 gallons per 24 hours.
Lewis Manufacturing Company.	Surgical goods, . .	Tanks and 4 beds, .	20,000 gallons per 24 hours.
Central Wet Wash, .	Laundry, . . .	None, . . .	Small.
Luxmoor Company, .	Specialties, . .	None, . . .	Small.
Bird & Son, . . .	Paper and boxes, .	Extensive tanks and beds.	3.9 million gallons per 24 hours.
Hollingsworth & Vose, .	Paper, . . .	Extensive tanks and beds.	3.2 million gallons per 24 hours.
Union Sandpaper Company.	Sand and emery paper.	None, . . .	Very small.
Bird & Son, . . .	Prostate roofing, .	None, . . .	Small.
<i>Norwood.</i>			
Winslow Bros. & Smith,	Wool and tanned leather.	Crude tanks and beds for part of wastes.	700,000 gallons per 24 hours.
Morrill Ink Works, .	Printing inks, . .	None, . . .	Very small.
<i>Stoughton.</i>			
Chas. Stretton & Son, .	Hosiery and knit goods.	None, . . .	Small.
Panther Rubber Company.	Rubber goods, . .	None, . . .	Small.
Stoughton Rubber Company.	Rubber goods, . .	Crude treatment, .	Small.
Stoughton Mills, . .	Shoddy, . . .	None, . . .	59,000 gallons per 24 hours.
French & Ward, . .	Hosiery and knit goods.	Crude treatment, .	80,000 gallons per 24 hours.
<i>Canton.</i>			
Springdale Finishing Company.	Dyeing and finishing textiles.	Tanks and beds, .	150,000 gallons per 24 hours.
Plymouth Rubber Company.	Rubber goods, . .	Practically none, .	20,000 gallons per 24 hours.
C. C. C. Fire Hose Company.	Rubber hose, . .	None, . . .	Very small.
Neponset Woolen Mills, .	Woolen and worsted goods.	Tanks and beds, .	40,000 gallons per 24 hours.
Draper Brothers, . .	Felt goods, . .	Tanks and beds, .	20,000 gallons per 24 hours.
<i>Dedham.</i>			
Hodges Finishing Company.	Dyeing and finishing textiles.	None, . . .	800,000 gallons per 24 hours.
Cochrane Manufacturing Company.	Carpets and rugs, .	Crude strainers, .	115,000 gallons per 24 hours.
Dedham Finishing Company.	- -	None, . . .	Small.
<i>Hyde Park.</i>			
Manchaug Company, .	Cotton goods, . .	None, . . .	Small.
T. F. Gray & Co., .	Shoddy, . . .	None, . . .	Small.
Tilston & Hollingsworth.	Paper, . . .	Tanks, . . .	500,000 gallons per 24 hours.

The Sharon Box Factory, American Core Twine Company and the H. A. Lothrop & Co. cutlery plant in the town of Sharon use water for power purposes almost entirely, and discharge but a very small amount of wastes into the stream, causing practically no pollution.

In none of the above cases is the condition of the wastes actually discharged into the river satisfactory from the point of view of the prevention of serious pollution, even when considering the Neponset River wholly as an industrial and manufacturing stream.

In the Hyde Park and Readville district the plants of the Becker-Brainerd Milling Machinery Company, the New York, New Haven & Hartford Railroad carshops, the B. F. Sturtevant Company Blower Works, the American Tool Company, the Hawthorne Mill of the American Felt Company, and the power station of the Bay State Street Railway Company discharge wastes into the river consisting largely of condenser water and engine drippings, with considerable quantities of oil and grease. In Dorchester the Walter Baker Company Chocolate Mills discharge their wastes into tidewater.

TABLE XLVIII. — *Principal Lakes and Ponds on the Neponset River in Massachusetts.*

[Except where otherwise noted, the areas of ponds are obtained from original plane table sheets of the State topographical map. Scale, 1: 30,000.]

No.	NAME OF POND.	Location.	Flow regulated by —	Drain- age Area (Square Miles).	Area of Pond (Acres).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	Neponset Reservoir,	Foxborough,	Neponset Reservoir Company, .	2.20	433 ¹	95.20	Storage only.
2	Clark's Pond,	South Walpole,	—	3.70	22	5.70	Storage only.
	Mill Pond,		Norfolk & Bristol Street Railway Company.				Boiler use only.
	Ruckaduck Pond,		Bird & Son,				Power.
	Blackburns Pond,						Storage only.
3	Mill Pond,	Walpole,	Standard Woven Fabric Company, .	12.26	21	6.50	Storage only.
	Union Pond,						Rollers and washing.
	Lewis Pond,						Boilers and washing.
	Moreys Pond,						Washing and bleaching.
4	Moreys Pond,	Walpole,	Milton Ice Company,	.24	15	2.60	—
5	Plymptons Pond,	East Walpole,	George A. Plympton,	26.00	16 ¹	2.70	Storage only.
6	Birds Pond,	East Walpole,	Bird & Son,	26.85	29 ¹	8.90	—
7	Buckmaster Pond,	Westwood,	Towns of Norwood and Westwood,	.60	30 ¹	16.40	Water supply.
8	Willetta Pond,	Norwood and Walpole,	Winslow Brothers & Smith,	3.40	210 ¹	101.35	Washing and dilution of wastes.

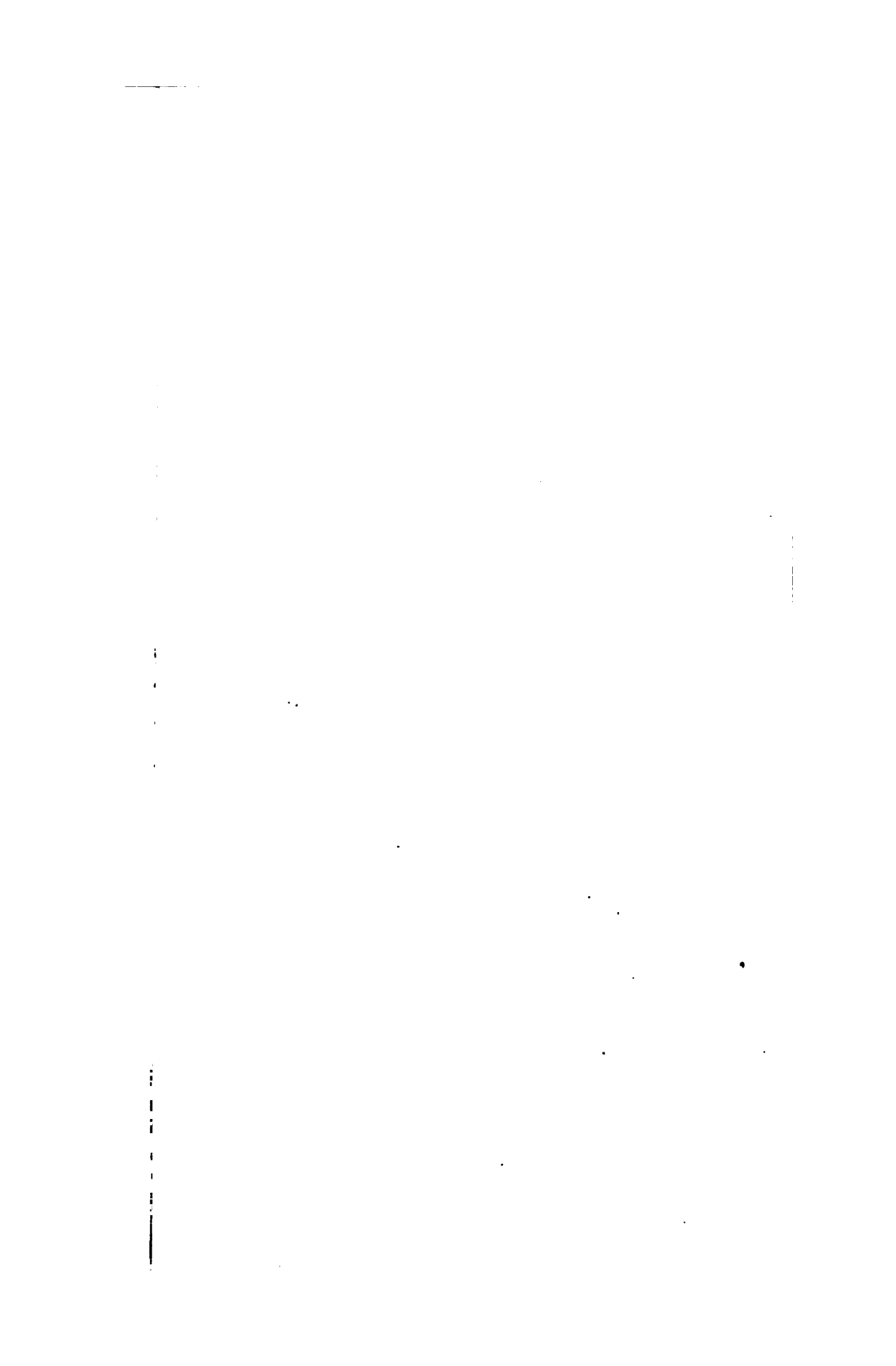
TAUNTON RIVER.

The Taunton River is the largest and most important stream in southeastern Massachusetts. It is formed primarily of two main branches, — the Town River and the Matfield River, which join at Pratttown a little east of the George O. Jenkins Paper Mill, which is about $1\frac{1}{2}$ miles east of the village of Bridgewater. After a drop of about 8 feet at the paper mill it flows in a winding course from 70 to 100 feet wide southerly and westerly a distance of some 15 miles, to a point at East Taunton, where it drops again a maximum of 11 feet to tide-water.

From East Taunton the tidal portion of the river extends westerly about 6 miles to Weir Village in the city of Taunton, then turns southerly and enters Mount Hope Bay by a more or less broad channel, its waters passing the city of Fall River. This stretch of river from East Taunton to Fall River is navigable, with an average depth as far as the Weir of from 10 to 15 feet at mean high tide.

The upper sources of the river consist of various small rivers and brooks which rise in the southerly part of Norfolk County and the northerly part of Bristol County in the towns of Wrentham, Foxborough, Sharon, Easton, Stoughton, Avon and Holbrook. The easterly streams have their source in the northerly part of Plymouth County in the town of Abington, and in the Long Pond section in Lakeville, uniting to form tributaries of considerable size and varying importance.

The total drainage area above Slades Ferry Bridge in Fall River is 529 square miles, without any allowance for diversion for water-supply purposes.



1

2

TABLE XLVII. — *Drainage Areas of Taunton River at Various Points.*

NAME.	Drainage Area (Square Miles).
Slades Ferry bridge, ...	529
West Berkley, ...	450
One mile below the Weir in Taunton, ...	364
Opposite Taunton filter beds, ...	312
Upper limits of tidewater at East Taunton, ...	289
Below Namasket, ...	256
Above Namasket, ...	184
Below Wenatuxet, ...	179
Above Wenatuxet, ...	140
Taunton River at the junction of Town and Matfield rivers, ...	138

The principal tributaries with their respective drainage areas are as follows: —

NAME.	Drainage Area (Square Miles).
Assonet, ...	35.0
Matfield, ...	78.0
Mill, ...	45.0
Namasket, ...	72.5
Salisbury Plain, ...	20.5
Satucket, ...	36.5
Three Mile, ...	85.0
Town, ...	60.0
Wenatuxet, ...	39.0

The entire drainage basin is about 30 miles long north and south by 31 miles wide east and west. Its mean annual rainfall is about 46 inches. Its westerly and marginal sections are hilly and rolling, while its central and easterly portion is quite flat and swampy, being well wooded with young growth considerable of which is cedar. The swamp and low lands are subject

to overflow. The uplands, while wooded in places, are fairly open, and much of the land is under cultivation. The bed and banks are of sand and gravel, and being of slight declivity the flow of the stream is fairly well sustained, due to numerous small ponds and reservoirs scattered about the basin which regulate the flow to some extent. Some of the branches, however, are more flashy, and are useful for only a small portion of the year.

The following list shows the cities and towns that are largely or partly drained by the Taunton River, and the population of each is given for the year 1915, except where only a small part is within the drainage basin:—

NAME.	Pop- ulation in 1915.	NAME.	Pop- ulation in 1915.
Abington, ...	5,046	Hanson, ...	1,796
Attleboro, ...	-	Lakeville, ...	1,491
Avon, ...	2,164	Mansfield, ...	5,772
Berkley, ...	985	Middleborough, ...	8,631
Bridgewater, ...	9,381	Norton, ...	2,667
Brookton, ...	62,288	Plainville, ...	-
Dighton, ...	2,499	Plympton, ...	599
East Bridgewater, ...	3,699	Raynham, ...	1,810
Easton, ...	5,064	Somerset, ...	3,377
Fall River, ...	-	West Bridgewater, ...	2,741
Foxborough, ...	3,755	Whitman, ...	7,530
Freetown, ...	-	Wrentham, ...	-
Halifax, ...	638		

Diversion for Water Supply.

The largest diversion occurs in the group of ponds in the towns of Lakeville and Middleborough, known as the Long Pond system, from which the city of New Bedford at present diverts a considerable part of the flow of Little and Great Quittacas ponds, using on an average about 8,500,000 gallons per day from a drainage area of 12.8 square miles. The New Bedford pumping station is on the south shore of Little Quittacas.

The city of Taunton diverts about 2,800,000 gallons per day from Assawompsett Pond, which is only a small part of its yield, the pumping station being on the westerly shore of the pond. It also diverts the entire watershed of Elders Pond, about one-half square mile, using the pond as a distributing reservoir.

The drainage area of the Long Pond system is about 47.2 square miles, made up as follows: —

	Square miles.
Long Pond, ...	21.3
Assawompsett, ...	13.1
Great Quittacas, ...	11.4
Little Quittacas, ...	1.4

Of this area the total amount to be deducted from the flow of the river is equivalent to about 15 square miles at present, which may be increased at a later date.

The drainage area of the Salisbury Plain Reservoir, in the town of Avon, diverted for the Brockton water supply, is about 3.25 square miles, and the drainage area of Hobart Pond in Whitman is about 6.2 square miles, also diverted for water purposes. The total area to be deducted is therefore about 25 square miles, leaving a net area at Slades Ferry Bridge of 504 square miles for the flow of the river.

Water Power.

From Table No. XLIX., on pages 276 and 277, it appears that the fifteen more important companies on the lower portion of the basin show a total head of 132 feet capable of developing 2,345 horsepower, of which only 1,618 horsepower are in use at present, while these same plants require about 12,500 horsepower in steam.

On the upper portion of the basin there were at one time over 80 small privileges with heads varying from 4 to 22 feet, where sawmills, grist mills and factories were once located, a large portion of which have gone out of use.

On the main stream there are but two important water-power privileges, the first being the Taunton Cotton Mills at East

Taunton, formerly known as the New England Cotton Yarn Company, or the Namasket Mills. A masonry dam was built at this point under the original authority of chapter 43 of the Acts of 1813, which authorized the construction of a dam upon the condition that a sluiceway should be maintained for the free passage of boats and rafts and all kinds of lumber. A lock and canal were built on the south side of the river and maintained for a number of years, but the canal was filled several years ago and the lock has not been used since, although still standing. The head varies according to the stage of the tide, but averages about 10 feet. There were originally installed twelve 50-horsepower turbines, but one wheel has since been taken out, reducing the capacity to 550 horsepower of which about one-half is used every day, one wheel running at night; 1,400 horsepower of steam are used.

The next site is at Pratttown, where the George O. Jenkins Paper Mill is located, about one-quarter below the junction of the Town and Matfield rivers. The head at this point is about 8 feet. There are two 75-horsepower turbines which give 100 horsepower on a twenty-four-hour basis for about eight months of the year, and from 375 to 400 horsepower of steam is used in addition.

The only important privilege on the Town River in operation at present is the Stanley Iron Works, about 3 miles by stream above the mouth. The main reliance for power is on 2,500 horsepower of steam, using only about half of their turbine capacity of 200 horsepower for about eight to nine months. Above this plant the Ames privilege at West Bridgewater is not in use, although the dam and sluiceway are intact.

There are only two dams on the Matfield River, — one, just below the railroad bridge in East Bridgewater, which belongs to the Edison Electric Light Company, has a fall of about 4 feet, and is used only to store water for the boiler; the other, a short distance above, was washed out during the present year. The river has a very flat slope, and sometimes floods its banks twelve hours after a rain.

Neither the Satucket nor the Wenatuxet rivers furnish any important water power, although they drain in the aggregate

about 90 square miles of territory and offer opportunity for storage.

There are three privileges on the Namasket River, two are in use and one is abandoned. The upper one is owned by the town of Middleborough, and operates the electric lighting plant in connection with auxiliary steam power. A masonry dam is located at Wareham Street, and floods back to the dam at the outlet of Assawompsett Pond, a distance of about 3 miles by the river. The drainage area is about 59 square miles, including that of Fall Brook which enters below Assawompsett Pond. There is an installed wheel capacity of 160 horsepower, but the power developed by the head of 10 feet varies from a minimum of 40 horsepower to a maximum of 132 horsepower.

The second privilege is owned by the Namasket Mills Corporation operating a woolen mill about one-half mile below the electric light plant. They have a 75-horsepower wheel on about 12-foot head, and also use steam power.

The third and abandoned privilege is about 1 mile below the Namasket Mills, where at one time there was a dam with a 12-foot head.

The two tributaries occupied by large manufacturing plants are the Three Mile River and the Mill River. The former has a drainage area of about 85 square miles. The first five mill privileges, having a total head of about 45 feet capable of developing 635 horsepower, are located on the lower 5 miles of the stream, the three lower privileges making little if any use of their wheels. One of them, the Mount Hope Finishing Company, has developed a very large steam plant of 3,000 horsepower and taken out the water wheels, using water mainly for manufacturing purposes.

The other two, the Westville Spinning Company and the Oakland Mills, make very good use of their water power for about ten months in the year. Other smaller privileges are found above on the Wading Brook and Mumford River branches, but are all of minor importance.

Mill River runs through the city of Taunton, and has a drainage area of 45.5 square miles. There are six privileges on the lower 3 miles of the stream, three of which do not use their

wheels, — the Atlas Buckram Company, the Eatough Cleansing Company and the Hopewell Mills. Of the other three, Reed & Barton use their two wheels very little, but the Taunton Wool Stock Company and the Whittendon Manufacturing Company make a fair use of their water power, as shown in Table No. XLIX., on page 277. The Whittendon Company controls the storage from Sabbatia Lake and Watson Pond with 30-inch draw-down, and also Winniconnet Pond a short distance to the north. Plans for rearrangement of power, and electrifying the plant with a view to a more complete use of their water power are now being considered.

Storage.

In the drainage basin there are quite a number of small ponds and reservoirs which serve to store up a considerable portion of rainfall, but comparatively few of them are used to systematically regulate and equalize the flow of the stream. The details are shown in Table No. L., on pages 280 and 281.

Undeveloped Storage.

On account of the small fall in Taunton River there is but little if any demand for additional storage for the more important water powers, and there are few favorable locations for new reservoirs.

The most worthy of mention are those covered by an investigation made in 1909 for the joint benefit of the Stanley Iron Works on the Town River, the George O. Jenkins Paper Company in Pratttown, and the Taunton Cotton Mills in East Taunton, the two latter being on the main stream.

The plan called for a new reservoir in West Bridgewater above Forest Street at an elevation of 10 feet above the old Ames Dam (just below it and not now in use) to store about 706,000,000 cubic feet in the Hockamock and Great Cedar swamps, flooding Nippenicket Pond. By restoring the Ames privilege in conjunction with this reservoir it was estimated that about 260 horsepower on a twenty-four-hour basis could be developed. A new reservoir on Matfield River covering about 400 acres with a 5-foot draw-down would store about 87,000,000

cubic feet, which could be filled and utilized several times in a year. It was also suggested that Robbins Pond could be raised to flow about 200 acres, which with a 6-foot draft would provide about 52,000,000 cubic feet, and if Tispaquin Pond were raised to cover about 600 acres it would yield about 92,000,000 cubic feet more.

On account of the costs and other factors the construction of these reservoirs has not appeared to the three companies, up to the present time, to be wholly desirable.

Canal Project.

The Taunton River is involved in several projects that have been considered in recent years to connect Mount Hope Bay with Boston Harbor by a canal. In 1901 surveys and estimates for a ship canal of 20 feet draft, from Narragansett Bay to Boston through Taunton River, were made by the Harbor and Land Commissioners, the canal to follow the Salisbury Plain Valley through the city of Brockton. The excessive cost, estimated at \$58,000,000, being prohibitive, other routes have since been investigated following stream valleys nearer the Atlantic coast, and so avoiding the necessity of building as many as twelve large locks and expensive bridges in Brockton and at numerous highways, and the diversion of railroads that run parallel with the canal and through the valley to be traversed by the same.

The report of the United States Engineers for the year 1912 gives in detail the results of their survey of various routes to form a part of the intracoastal canal system ordered to be investigated by the Federal government. It presents two practicable routes, — one entirely inland from Taunton to Hingham, passing through Halifax, Pembroke, Hanover, etc., and one inland from Taunton to Plymouth, and thence from that point 30 miles via Massachusetts Bay to Boston. Reliable estimates are given with depths varying from 18 to 25 feet, with various widths and heights of summit levels showing the cost of a lock canal to vary from \$17,453,000 for an 18-foot depth to \$40,000,000 for a full depth of 25 feet, with bottom width of 200 feet and summit level of 35 feet; also estimates were pre-

pared for a sea-level canal from Taunton River to Plymouth, with the cost varying from \$28,429,000 to \$47,133,000, with depth from 18 to 25 feet, and bottom width of 125 to 200 feet. Both contemplate connection with Taunton River below Weir Village.

In 1915 it seemed desirable to make an examination of a cross-country connection between a point on the United States Engineers' route at Pratttown Dam and the original Brockton route, and surveys were made in that year as authorized by chapter 103 of the Resolves of 1915. By chapter 135 of the Resolves of 1916 the Board of Harbor and Land Commissioners was authorized to make further surveys and examination of territory between Taunton River and North River, and to prepare revised estimates of the cost of a through waterway to Massachusetts Bay. The field work has been completed, and a report will be made later to the General Court.

The independent question of improving the Taunton River below the Weir by making the depth not less than 18 feet with rectification of bends, to be carried out in co-operation between the Commonwealth of Massachusetts, the Federal government and municipalities, was set forth in a special report of the Board of Harbor and Land Commissioners under the provisions of chapter 433 of the Acts of 1913 (House Document No. 2138 of 1914). The recommendation of the Harbor and Land Commissioners led to the passage of chapter 716 of the Acts of 1914, authorizing an expenditure of \$100,000 by the Commonwealth for this purpose, provided that Congress should also make an appropriation to improve the river from Fall River to Weir Village.

At a public hearing Oct. 15, 1915, on this subject, it was indicated by Col. John Millis, Corps of Engineers, U. S. A., referring to his pending report on the Taunton River, that favorable action by the State with respect to a waterway between Taunton and Brockton, extended eventually to Boston Harbor, would have an important bearing upon the question of the advisability of further improvement of Taunton River from Fall River to Weir Village by the Federal government.

An extension of authority to spend \$100,000 as previously

passed was given by the Legislature, chapter 80 of the Resolves of 1916, making the appropriation available for a period of three years after 1916.

On June 30, 1916, Colonel Millis submitted his report to the Chief of Engineers, in which he arrived at the conclusion that the project was not worthy of being undertaken by the Federal government at that time, although he believed the subject should be further considered in connection with future consideration by the State of the through waterway as above.

TABLE XLIX. — *Water Power on the Taunton River in Massachusetts.*
 [S. indicates steam.]

No.	NAME OF COMPANY.	Location.	Product.	Number of Working Hours.	Drainage Area (Square Miles).	Average Head (Feet).	Rated Horsepower of Water Wheels.	Discharge in Second-feet per Square Mile, 80 Per Cent. Efficiency.	Auxiliary Horsepower.	Remarks.
<i>Taunton River.</i>										
1	Taunton Cotton Mills Company, .	East Taunton, .	Cotton goods, .	24	289.0	10.0	550	2,090	1,400 S.	Wheels used at half capacity.
2	George O. Jenkins Company, .	Prattown, .	Leatherboard, .	24	133.0	8.0	375	3,740	400 S.	-
4	Harodite Finishing Company, .	North Dighton, .	Cotton goods, .	9	84.5	7.0	60	1,115	300 S.	Owned by Algonquin Printing Company, Fall River. Wheels not in use.
5	L. Lincoln & Co., ...	North Dighton, .	Paper stock, .	24	84.5	8.0	75	1,220	35 S.	-
6	Mt. Hope Finishing Company, .	North Dighton, .	Cotton goods, .	9	83.4	6.0	110	2,420	3,000 S.	Two wheels taken out.
7	Westville Spinning Company, .	Westville, . .	Cotton yarn, .	9	80.0	11.0	90	1,120	210 S.	-
8	Oakland Mills Company, . .	Oakland, . .	Cotton goods, .	9	75.5	8.0	160	2,920	250 S.	Use steam at half capacity.
9	Woodward's Saw mill, . . .	Above Oakland, .	Lumber, . . .	9	70.0	6.0	40	1,047	-	-
<i>Wading River.</i>										
10	Taunton & New Bedford Copper Works, .	Norton, . .	-	-	42.0	21.0	50	.623	-	Not in use.
11	Delaware Manufacturing Company, .	Barrowville, .	Tracing cloth, .	9	27.8	8.5	-	-	-	-

12	<i>Rumford River.</i> Tulbot Wool Combing Company, .	Norton, .	Wool, . . .	9	18.0	8.0	-	-	-	-	-	-
13	<i>Mill River.</i> Atlas Buckram Company, .	Taunton, .	Ticking, . .	9	45.0	6.0	80	1,220	120 S.	-	-	-
14	Eastough Cleansing and Dyeing Company, .	Taunton, .	Dyed goods, .	9	45.0	6.0	80	1,220	-	-	-	-
15	Taunton Wool Stock Company, .	Taunton, .	Wool, . . .	9	44.0	10.0	150	3,750	1,000 S.	Formerly Taunton Dye Works.	-	-
16	Hopewell Mill Company, .	Taunton, .	- - -	-	43.5	12.5	-	-	-	Not in use.	-	-
17	Reed & Barton, . . .	Brittaniaville, .	Silver and plated ware.	9	43.2	7.0	105	3,890	500 S.	Use wheels but little.	-	-
18	Whittenton Manufacturing Company. <i>Town River.</i>	Brittaniaville, .	Cotton and woolen goods.	9	42.5	12.0	225	4,850	2,500 S.	Wheels not in use at present.	-	-
19	Stanley Iron Works, . . .	Bridgewater, .	Iron materials, .	24	54.2	15.5	200	2,620	2,500 S.	Office, New Britain, Conn.	-	-
20	Ames Mill Company, . . .	West Bridgewater, .	- - -	-	52.0	9.5	-	-	-	Buildings burned.	-	-
21	<i>Matfield River.</i> Edison Electric Light Company, .	Matfield, . .	Electricity, . .	24	31.0	6.0	-	-	4,500 S.	Operated by Stone & Webster. Water power not in use.	-	-
22	Reed & Shaw Company, . .	Matfield, . .	- - -	-	20.5	12.0	-	-	-	Dam washed out April, 1917. Buildings burned.	-	-
	Total, ...	- - - - -	- - - - -	-	-	-	2,250	-	-	-	-	-

TABLE L. — *Principal Lakes and Ponds on the Taunton River in Massachusetts.*

[Except where otherwise noted, areas of ponds are obtained from original plane table sheets of State topographical map. Scale, 1:30,000.]

No.	NAME OF POND.	Location.	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
1	<i>Assonet River.</i> Forge Pond, ...	-	20.90	80.0	-	-	-
2	<i>Taunton River.</i> Broad Cove Pond, ...	Dighton and Somerset,	1.00	94.0 ¹	-	-	-
3	Pond southwest of East Taunton, .	Taunton, ...	6.70	21.0	-	-	-
4	Kings Furnace Pond, ...	Taunton, ...	3.85	43.0	-	-	-
5	Bear Hole Pond, ...	Taunton, ...	2.00	33.0	-	-	-
6	Forge Pond, ...	Raynham, ...	9.50	25.0	-	-	-
7	Gushnee Pond, ...	Raynham, ...	1.30	47.0	-	-	-
8	Prospect Hill Pond, ...	Taunton and Raynham, ...	.60	66.0 ¹	-	-	-
9	<i>Three Mile River.</i> Mount Hope Mill Pond, ...	Dighton and Taunton, ...	83.40	12.0 ¹	-	-	-
10	Oakland Mill Pond, ...	-	75.50	23.0	-	-	-
11	<i>Wading River Branch.</i> Barrowsville Pond, ...	Norton, ...	37.80	40.0	-	-	-
12	Pond west of Barrowsville, ...	Norton, ...	5.50	38.0	-	-	-
13	Pond south of Coxsasset, ...	Foxborough, ...	2.70	20.0	-	-	-

Or Deans Factory Pond; area uncertain.

14	Cocasset Pond, ...	Foxborough, ...	2 30	34.0	-	-	-	-
15	Reservoir north of Cocasset, ...	Foxborough, ...	1.15	20.0	-	-	-	-
16	Shepards Pond, ...	Foxborough and Plainville, ...	12.10	173.01	-	-	-	Or Miramohi Pond.
17	Shepardville Pond, ...	Plainville, ...	4.40	176.0	-	-	-	-
18	<i>Rumford Branch.</i> Norton Reservoir, ...	Norton and Mansfield, ...	17.60	508.01	6	133.0	-	-
18a	Billings Pond, ...	Sharon, ...	-	35.0	-	-	-	-
19	<i>Mill River.</i> Brittaniaville Pond, ...	Taunton, ...	43.20	18.0	-	-	-	-
20a	Whittenton Mill Pond, ...	Taunton, ...	42.50	-	-	-	-	-
21a	Watsons Pond, ...	Taunton, ...	-	94.0	-	-	-	-
22a	Seadding Pond, ...	Taunton, ...	41.60	200.0	2.5	320.2	-	Sabbatia Lake.
23a	Winneconnet Pond, ...	Norton, ...	32.60	326.0	-	-	-	-
24	Leaches Pond or Wilburs, ...	Easton and Sharon, ...	2.90	114.01	-	-	-	-
25	Pond east of Whiteville, ...	Mansfield, ...	1.90	26.0	-	-	-	-
26a	<i>Namasket River and Tributaries.</i> Assawompett Pond, ...	Lakeville and Middleborough, ...	47.90a	2,656.01	-	-	-	Taunton water supply.
27a	Pochaha Pond, ...	Lakeville and Middleborough, ...	-	-	-	-	-	-
28a	Long Pond, ...	Freetown and Lakeville, ...	22.30	1,742.01	-	-	-	-
29	Great Quittacas Pond, ...	Lakeville, Middleborough and Rochester, ...	-	1,194.01	-	600.0	-	-
30	Little Quittacas Pond, ...	Freetown, Lakeville and Rochester, ...	12.80	318.0	-	132.5	-	New Bedford water supply.
31a	Elders Pond, ...	Lakeville, ...	.50	145.01	-	92.3	-	-
32	Loon Pond, ...	Lakeville, ...	.20	30.0	-	-	-	-

¹ Area from large scale plan or reliable source.

² Flow from Ponds Nos. 20, 21, 22 and 23 is regulated by the Whittenton Manufacturing Company.

³ Flow from Ponds Nos. 26, 27, 28 and 31 is regulated by the City of Taunton.

⁴ Total drainage area at outlet.

TABLE L. — *Principal Lakes and Ponds on the Taunton River in Massachusetts* — Concluded.
 [Except where otherwise noted, the areas of ponds are obtained from original plane table sheets of the State topographical map. Scale, 1:31,000.]

No.	NAME OF POND.	Location.	Drain- age Area (Square Miles).	Area of Pond (Acres).	Draft (Feet).	Esti- mated Storage (Million Cubic Feet).	Remarks.
<i>Nemasket River and Tributaries</i>							
33	Clear Pond, ...	Lakeville, ...	.30	28.0	-	-	-
34	Woods Pond, ...	Middleborough, ...	1.00	41.0	-	-	-
35	Tispaquin Pond, ...	Middleborough, ...	2.10	250.0 ¹	-	-	-
<i>Wenasset River and Tributaries.</i>							
36	Waterville Pond, ...	Middleborough, ...	1.70	29.0	-	-	-
37	Johns Pond, ...	Carver, ...	.90	28.0	-	-	-
38	Coopers Pond, ...	Carver, ...	.15	16.0	-	-	-
<i>Saluket River and Tributaries.</i>							
39	Robbins Pond, ...	East Bridgewater, ...	14.00	158.0	6	41.3	-
40	Monponset Pond, ...	Halifax and Hanson, ...	5.80	756.0 ¹	4	131.7	-
41	Muddy Pond, ...	Halifax and Pembroke, ...	.10	15.0	-	-	-
42	Stetsons Pond, ...	Pembroke, ...	.80	93.0	-	-	-
43	Cushing Pond, ...	Hanson, ...	.90	40.0	-	-	-
44	Pond south of Cushing, ...	Hanson, ...	11.80	30.0	-	-	-
45	Hobarts Pond, ...	Abington and Whitman, ...	6.20	207.0	-	7.8	Whitman Reservoir.
46	Island Grove Pond, ...	Abington, ...	2.70	20.8	-	-	-

ACUSHNET RIVER.

The Acushnet River has its source in the Acushnet Reservoir, in the northerly end of the town of Acushnet. From the reservoir the stream flows in a southwesterly direction about $3\frac{1}{2}$ miles to tidewater at the dividing line between the city of New Bedford and the town of Acushnet, known locally as the "Head of the River," as it is the head of the tidal portion of the river which in reality is an estuary of Buzzards Bay.

The Acushnet Reservoir was formerly the water supply of the city of New Bedford, but its use was discontinued in 1899, and since then it has been retained as an auxiliary supply. It has an area of 300 acres and receives the drainage of 3,000 acres, which, experience has shown, is good for 3,000,000 gallons per day in the driest years.

The drainage area of the stream above tidewater may be taken as about 12.5 square miles, with a fall from the crest of the dam at the Acushnet Reservoir to mean sea level of about 40 feet, of which 8 feet is at the dam, about 8 feet at a small privilege known as Hamblin's Pond, about 8 feet at Morse's Pond, owned by the city of New Bedford, and about 8 feet at Hawes's Pond just above tidewater. None of these privileges are now in use for the creation of power.

The yearly rainfall on the upper part of the basin has averaged, for a period of twenty-eight years, 50.58 inches, which should give a daily run-off for the whole basin of about 13,000,000 gallons, although this may be reduced by the development of the lower part of the basin for residential use.

The Hawes privilege formerly had an installation of three water wheels, one of 20 horsepower and two of 40 horsepower each. These were all operated throughout the winter months, but only the 20-horsepower wheel was run during the summer. The Acushnet Saw Mill Company own this privilege, but operate their box factory with a 250-horsepower steam engine.

Storage.

The Acushnet Reservoir has a storage capacity of about 315,500,000 gallons for a maximum draw-down of $3\frac{1}{2}$ feet. The Hamblin and Hawes ponds are small, and there is no possibility

of securing additional storage at either of these privileges. The flow of the Acushnet Reservoir will ultimately be required by the mills in New Bedford for manufacturing purposes, for which it will probably have a greater value than any other use to which it could be put.

WEWEANTIC RIVER.

The Weweantic River has its source in the extreme northerly part of the town of Carver, about 3 miles from Cape Cod Bay, and flows southerly for about 15 miles to tidewater in Buzzards Bay near the mouth of the Wareham River.

The river drains an area of about 88 square miles, the highest point reaching an elevation of 200 feet above sea level. The basin includes a number of ponds of which Sampson's Pond of 280 acres is the largest and drains into the main stream by Sampson's brook.

The first power site is about one-half mile south of the village of South Wareham, where there is a fall of 9 or 10 feet owned by the Standard Horse Shoe Company, who have two wheels that generate from 75 to 175 horsepower according to the season. Within the next few miles there are the ruins of three dams that formerly furnished power for a paper mill, a cotton mill and a grist mill, with heads of 7 to 8 feet. Just below the old grist mill site is a dam in poor condition with a head of 8 feet that was formerly used to operate a sawmill but is not now in operation.

The next privilege belongs to the Tremont Nail Company, whose dam is located near the Tremont station on the Cape Cod branch of the Old Colony Railroad Company, where three turbines of about 125 horsepower are installed under a head of 20 to 22 feet. One 25-horsepower wheel runs at full capacity about fourteen hours per day throughout the year, and the other two of 50 horsepower each run from nine to twenty-four hours a day, according to the supply of water. There is also 1,000 horsepower in steam engines. The dam is built of stone and is about 500 feet long with a framed wooden spillway about 60 feet long. There is a considerable pondage above the dam which receives the run-off from a drainage area of about 50

square miles, including Sampson's Pond and several other ponds of fair size. There are no other privileges on the stream, although there is a dam at the outlet of Sampson's Pond which furnished a small power at one time, but at present the flow is about all required for the flowage of extensive cranberry bogs adjoining the pond and the stream below.

There is no opportunity for increasing the storage by adding to the height of existing dams without flooding extensive areas of cranberry bogs which would involve damages in excess of the probable value of the power.

QUEQUECHAN RIVER.

The Quequechan River has its source in Watuppa Pond on the easterly boundary of the city of Fall River, and flows through the city into the harbor near the mouth of the Taunton River.

The drainage area above the controlling dam is only 31 square miles, but the flow is extremely variable due to lack of storage, although Watuppa Pond has an area of 3,600 acres. The pond is divided into two ponds by a causeway crossing about midway of its length, with sluiceway and controlling gates for regulating the flow from the north pond to the south pond. The city of Fall River draws its water supply from the north pond, the surplus going to the south pond and thence to the river.

The fall from what is known as "full pond" level in Watuppa Pond to mean high water in Taunton River is 129 feet, which is taken up in a distance of less than one-half mile by eight privileges, with heads varying from 10 to 21.67 feet. Two of these are not in use, and on the remainder, turbines of 1,300 effective horsepower are installed, which is a very small item compared with the steam power required to operate the mills in this city.

The mills along the stream make an important use of the water for manufacturing purposes, although it is quite badly polluted and has been the subject of several investigations, which as yet have not resulted in any improvement of the situation. It is evident, however, that the industrial value of

the water of the Quequechan River is far greater than its power value, and it is chiefly of interest in this investigation as illustrating the change that is taking place in the use of many of the small streams of the State.

MYSTIC RIVER.

This stream is located in Middlesex and Essex counties, and as it is not of material value as a source of water power, it has not been given the investigation and study that have been accorded the larger and deeper rivers. The total drainage area of the stream above tidewater at Craddock Bridge, Medford, is about 36 square miles, of which 7.2 square miles apply to Alewife Brook Basin, and 26.9 square miles are above Mystic Lake, which is the principal body of water in the basin that has been utilized.

The source of the river is given by the United States Geological Survey as west of the town of Reading, about 100 feet above mean sea level. It flows in a generally southerly course for a distance of about 9 miles to Arlington, passing through Richardson's and Burbank ponds to Mystic Lake (the part of the river above Mystic Lake being sometimes called Aberjona River), and continues in a southeasterly direction for a distance of 7 miles more to its junction with the Charles River and into Boston Harbor.

The total fall from its source to Mystic Lake is given as about 80 feet, and at the lake there is a dam and sluiceway connection between the upper and lower levels. From 1864 to 1897 Mystic Lake was used as a source of water supply for the city of Charlestown, now a part of Boston, but it is now included in the metropolitan water system, being kept full of water for emergency use. The pumping plant connected with it and the conduit and grounds are kept in constant repair.

The record of twenty years shows an average yield of 1.45 second-feet per square mile from a rainfall of 43.82 inches. The stream is tidal as far as the city of Medford, and is used for navigation.

The principal tributaries are the Malden River and Alewife Brook. At Craddock Bridge, Medford, a concrete tidal dam

has been built by the Metropolitan Park Commission as authorized by chapter 529 of the Acts of 1907. It has a lock, tide gates to exclude salt water, and a weir to regulate the flow from the Upper Mystic and Alewife Brook, the channels of which have been straightened and deepened for storage control so that the water table of the Arlington, Cambridge and Belmont meadows has been lowered and materially improved, reducing to a large degree the breeding of malaria-producing mosquitoes besides making available for farming purposes the rich uplands bordering on the meadows.

In carrying out this improvement the general level of the basin is kept at grade 6.75 with reference to Boston city base, leaving a margin of about 4 feet in case of storm before the lowlands are overflowed.

The general storage capacity of the Lower Mystic and the enlarged channels has proved to be ample, except in case of extreme rainfall, without the use of increased storage in Spy Pond, as suggested in the original plan given in Mr. John R. Freeman's report of 1904.

A small portion of the watershed at Middlesex Fells has been diverted for Winchester's water supply.

There are no streams of size or power possibilities, in the present-day meaning of the term, in that part of southeastern Massachusetts known as the Cape, although there are 163 fresh-water ponds of 10 acres or more in area south of the Cape Cod Canal, and numerous small streams, but in all cases the heads are very low. It is true that in the past small water powers were operated on some of these streams, but they have all been abandoned. Most of the so-called rivers of the Cape are in reality tidal estuaries, receiving a small fresh water stream at the head of tidewater.

Cranberry growing has made a very considerable use of many of the ponds and small streams on the Cape, but the natural storage capacity appears to be adequate, under proper supervision, for all present requirements of this industry.

It will be noted that many small streams and ponds, al-

though potential sources of energy, have not been considered in this investigation, and others have only been very briefly described, as it was assumed that true conservation must proceed along the lines of commercial practicability to be successful.

Power is like any commodity, — it must have a market that will pay a price enough greater than the cost to give a reasonable return upon the investment, no matter whether the power is produced by water or by coal.

Respectfully submitted,

WILLIAM F. WILLIAMS,
Engineer.

APPENDICES.

APPENDIX I.

LIST OF THE LAKES AND PONDS OF THE STATE, WITH AREAS, OF TEN OR MORE ACRES, GIVEN BY COUNTIES.

The following areas, except where otherwise stated, were measured on the original plane table sheets of the State map made in co-operation with the United States Geological Survey in 1884-88, scale 1:30,000.

BARNSTABLE COUNTY.

(Total acreage of ponds listed about 9,454.)

Name.	City or Town.	Approximate Area in Acres.	Outlet.
Bearse Pond, west of Hyannis.	Barnstable, ...	10	- - -
Chequamegon Lake or Great Nine Mill Pond.	Barnstable, ...	654	Herring River.
Craigville Pond, ...	Barnstable, ...	11	- - -
Half Way Pond, ...	Barnstable, ...	10	- - -
Hamline Pond or Mystic Lake.	Barnstable, ...	134	- - -
Hathaways Pond (north), .	Barnstable, ...	16	- - -
Israel Pond, ...	Barnstable, ...	23	- - -
Jones Pond, west of Centreville.	Barnstable, ...	16	- - -
Long Pond, ...	Barnstable, ...	70	- - -
Long Pond, Centreville, .	Barnstable, ...	35	Herring River.
Lovells Pond, ...	Barnstable, ...	54	Brook to Osterville Harbor.
Middle Cotuit Pond, . . .	Barnstable, ...	104	- - -
Muddy Pond, ...	Barnstable, ...	33	- - -
West Pond, pond south of Jones.	Barnstable, ...	15	- - -
Round Pond, ...	Barnstable, ...	10	- - -
Shallow Pond, ...	Barnstable, ...	67	- - -
Shubael Pond, ...	Barnstable, ...	56	- - -
South Cotuit Pond, ¹ . . .	Barnstable, ...	113	- - -
Stewards Pond, ...	Barnstable, ...	29	- - -
West Barnstable Pond, . .	Barnstable, ...	21	- - -
Bourne Pond, ...	Bourne, ...	10	- - -
Cataumet Pond, ...	Bourne, ...	29	Brook to Cataumet Harbor.

¹ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

BARNSTABLE COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Flax Pond, ...	Bourne, ...	27	- - -
Great Herring Pond, ¹	Bourne 2 acres and Plymouth 376 (Plymouth County).	2	- - -
Lily Pond, South Pocasset, ...	Bourne, ...	24	Barlow River.
Long Pond, ...	Bourne, ...	36	- - -
Lower Pond, South Pocasset, ...	Bourne, ...	10	Barlow River.
Mill Pond, ...	Bourne, ...	56	Back River.
Queen Sewell Pond, ...	Bourne, ...	18	- - -
Bangs or Seymours Pond, ^{1,2}	Brewster 94 acres and Harwich 87.	181 ³	Brook to Grassy Pond.
Bakers Pond, ¹	Brewster 4 acres and Orleans 28.	32 ³	- - -
Black Pond, ¹	Brewster 8 acres and Harwich 8.	16 ³	- - -
Blueberry Ponds south of East Brewster (2).	Brewster, ...	23	- - -
Chime Pond, ¹	Brewster 11 acres and Harwich 14.	25 ³	- - -
Cliff Pond, ...	Brewster, ...	204	- - -
Cobbs Pond, ^{1,2}	Brewster, ...	28 ³	- - -
Elbow Pond, ...	Brewster, ...	34	- - -
Flax or Flat Pond, ...	Brewster, ...	40	- - -
Francis Caboon Pond, ¹	Brewster 20 acres and Harwich 16.	36 ³	Long Pond.
Grassy Pond, ¹	Brewster 6 acres and Harwich 5.	11 ³	Brook to Long Pond.
Greenland Pond, ¹	Brewster, ...	37 ³	Brook to Long Pond.
Griffiths Pond, ...	Brewster, ...	22	- - -
Higgins Pond or Little Cliff, ...	Brewster, ...	18	- - -
Long Pond, ^{1,2}	Brewster 260 acres and Harwich 383.	743 ³	Brook to Hineley Pond.
Long Pond, east of Cliff, ...	Brewster, ...	19	- - -
Lower Mill Pond, ...	Brewster, ...	29	Herring Brook.
Mill Pond Middle, ²	Brewster, ...	253	Herring Brook.
Mill Pond Upper, ...	Brewster, ...	93	Herring Brook.
No Bottom Pond, ...	Brewster, ...	28	- - -
Pine Pond, ...	Brewster, ...	14	- - -
Sam Hall Pond, ...	Brewster, ...	15	- - -
Sheep Pond, ¹	Brewster, ...	148 ³	Long Pond.
Smalls Pond, ¹	Brewster, ...	19 ³	Long Pond.
Walkers Pond, ...	Brewster, ...	29	- - -
Emery Pond, ...	Chatham, ...	14	- - -
Goose Pond, ...	Chatham, ...	41	- - -

¹ Surveyed.² Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.³ Area taken from large scale plans or from reliable local sources.

BARNSTABLE COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Lizzie's Pond, ...	Chatham, ...	22	- - -
Lovers Lake, ¹	Chatham, ...	22	Brook.
Pond southwest of West Chatham, ...	Chatham, ...	24	- - -
Stillwater Pond, ¹	Chatham, ...	16	- - -
Taylor's Pond, ...	Chatham, ...	13	Brook.
White Pond, ...	Chatham, ...	39	- - -
Aunt Lizzie Robbins or White Pond, ...	Dennis 18 acres and Harwich 5, ...	23	- - -
Bakers Pond, ...	Dennis, ...	20	- - -
Bassetts or Eagle Pond, ...	Dennis, ...	13	- - -
Duck Pond, ...	Dennis, ...	10	- - -
Flax Pond, ...	Dennis, ...	14	- - -
Follens Pond, ²	Dennis 50 acres and Yarmouth 153, ...	203 ³	Base River.
Fresh Pond, ...	Dennis, ...	38	- - -
Grassy Pond, ...	Dennis, ...	23	- - -
Kelleys Pond, ...	Dennis, ...	35	Brook.
Run Pond, ...	Dennis, ...	20	- - -
Simmons Pond, ...	Dennis, ...	10	- - -
Scargo Lake, ...	Dennis, ...	60	- - -
Swan Pond, ...	Dennis, ...	157	Swan Pond River.
Depot Pond, ...	Eastham, ...	31	- - -
Great Pond, ...	Eastham, ...	109	- - -
Herring Pond or Coles Pond, ...	Eastham, ...	43	- - -
Meetinghouse Pond, ...	Eastham, ...	21	- - -
Ashumet Pond, ²	Falmouth 52 acres and Mashpee 162, ...	214 ³	- - -
Cedar Pond, ...	Falmouth, ...	22	- - -
Coonemossett Pond, ...	Falmouth, ...	138	Coonemossett River.
Crooked Pond, ...	Falmouth, ...	18	- - -
Deep Pond, ...	Falmouth, ...	34	- - -
Pond between Deep and Crooked, ...	Falmouth, ...	15	- - -
Factory Pond, north of East village, ...	Falmouth, ...	23	Coonemossett River.
Fresh Pond, ...	Falmouth, ...	38	- - -
Jenkins Pond, ...	Falmouth, ...	75	- - -
Pond northeast of same, ...	Falmouth, ...	16	- - -
Pond west of Jenkins, ...	Falmouth, ...	12	- - -

¹ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

² Surveyed.

³ Area taken from large scale plans or from reliable local source.

BARNSTABLE COUNTY—*Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Long Pond, ¹	Falmouth,	218 ²	- - -
Mares Pond,	Falmouth,	41	- - -
Oyster Pond,	Falmouth,	61	- - -
Pond west of village,	Falmouth,	10	- - -
Salt Pond,	Falmouth,	62	Brook to Nantuxet Sound.
Shallow Pond,	Falmouth,	11	- - -
Spectacle Pond,	Falmouth,	28	Brook.
Wings Pond,	Falmouth,	20	Brook.
Aunt Lizzie Robbins Pond,	Harwich (see Dennis),	-	- - -
Bangs or Seymours Pond, ³	Harwich (see Brewster),	-	- - -
Bassett Pond,	Harwich,	16	- - -
Black Pond, ³	Harwich (see Brewster),	-	Brook to Bangs Pond.
Briggs Pond,	Harwich,	17	- - -
Chime Pond, ³	Harwich (see Brewster),	-	- - -
Eldridges Pond,	Harwich,	25	- - -
Pond west of same,	Harwich,	16	- - -
Flax Pond,	Harwich,	16	- - -
Francis Cahoon Pond, ³	Harwich (see Brewster),	-	- - -
Grass Pond,	Harwich,	46	Doanes Creek.
Grassy Pond, ³	Harwich (see Brewster),	-	- - -
Hawks Nest Pond,	Harwich,	25	- - -
Island Pond,	Harwich,	21	Herring River.
Kenneys Pond,	Harwich,	10	- - -
Long Pond, ³	Harwich (see Brewster),	-	- - -
Paddocks Pond,	Harwich,	20	- - -
Pleasant Lake or Hinckley's Pond, ^{3,4}	Harwich,	171 ²	Herring River.
Robbins Pond,	Harwich,	25	- - -
Sandy Pond,	Harwich,	27	- - -
Skinequit Pond,	Harwich,	15	- - -
Walkers Pond,	Harwich,	30	- - -
Ashumet Pond, ³	Maashpee (see Falmouth),	-	- - -
Johns Pond,	Maashpee,	243	Childs River.
Pond northeast of same,	Maashpee,	18	- - -
Maashpee Pond,	Maashpee,	399	Maashpee River.

¹ Used as a source of water supply.² Area taken from large scale plans or from reliable local source.³ Surveyed.⁴ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

BARNSTABLE COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Santuit Pond, ...	Maahpee, ...	172	Santuit River.
Wakeby Pond, ¹	Maahpee, ...	316 ²	Maahpee River.
Bakers Pond, ¹	Orleans (see Brewster), . .	-	- - - -
Cedar Pond, ...	Orleans, ...	17	Town Cove.
Crystal Lake or Fresh Pond,	Orleans, ...	37	- - - -
Pilgrim Lake, ...	Orleans, ...	43	- - - -
Pond in south part, . . .	Orleans, ...	17	- - - -
Sparrows Pond, ...	Orleans, ...	23	Brook to Salt Pond.
Clappe Pond, ...	Provincetown, ...	44	- - - -
Great Pond, ...	Provincetown, ...	10	- - - -
Pasture Pond, ...	Provincetown, ...	10	- - - -
Shank Painter Pond, . . .	Provincetown, ...	27	- - - -
Lawrence Pond, ...	Sandwich, ...	123	- - - -
Peters Pond, ...	Sandwich, ...	137	- - - -
Pinlico Pond, ...	Sandwich, ...	14	- - - -
Pond at East Sandwich, . .	Sandwich, ...	10	- - - -
Shawme Lake, ...	Sandwich, ...	47	Mill River.
Snake Pond, ...	Sandwich, ...	33	- - - -
Spectacle Pond, ...	Sandwich, ...	95	- - - -
Triangle Pond, ...	Sandwich, ...	79	- - - -
Weeks Pond, ...	Sandwich, ...	10	- - - -
East Harbor Pond, ...	Truro, ...	351	- - - -
Higgins Pond, ...	Truro, ...	18	- - - -
Pond north of same, Great Round.	Truro, ...	14	- - - -
Long Pond or Horse Leach, .	Truro, ...	27	- - - -
Mill Pond, ...	Truro, ...	10	Brook to Pamet River.
Newcombe Pond or Slough,	Truro, ...	27	- - - -
Duck Pond, ...	Wellfleet, ...	10	- - - -
Great Pond, ...	Wellfleet, ...	41	- - - -
Gull Pond, ...	Wellfleet, ...	103	- - - -
Herring Pond, ...	Wellfleet, ...	19	Herring River.
Higgins Pond, ...	Wellfleet, ...	23	Brook to Herring River.
Long Pond, ...	Wellfleet, ...	34	- - - -
Big Sandy or Horse Pond, .	Yarmouth, ...	30	- - - -
Dennis Pond, ...	Yarmouth, ...	50	- - - -
Follens Pond, ¹	Yarmouth (see Dennis), . .	-	- - - -

¹ Surveyed.² Area taken from large scale plans or from reliable local sources.

BARNSTABLE COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Flax Pond, ...	Yarmouth, ...	18	- - -
Flax Pond at West Yarmouth.	Yarmouth, ...	15	- - -
James Pond, ...	Yarmouth, ...	10	- - -
Long Pond, ...	Yarmouth, ...	55	- - -
Mill Pond, ...	Yarmouth, ...	96	Brook to Follens Pond.
Nursery or Aunt Dinah's Pond. ¹	Yarmouth, ...	26 ²	- - -
Plashes Pond, ...	Yarmouth, ...	17	Parkers River.
Sears Pond, ...	Yarmouth, ...	14	- - -
Swan Pond, ...	Yarmouth, ...	87	Parkers River.
Taylor's Pond, ...	Yarmouth, ...	20	- - -

BERKSHIRE COUNTY.

(Total acreage of ponds listed about 6,844.)

Centre Lake, ...	Becket, ...	112	West Branch, Westfield River.
Greenwater Pond, ...	Becket, ...	90	Branch, Housatonic River.
Horn Pond, ...	Becket, ...	18	Branch, Walker Brook.
New Reservoir, ³	Becket, ...	163	- - -
Rudd Pond, ...	Becket, ...	80	Brook.
Shaw Pond, ¹	Becket 77 acres and Otis 23,	100 ²	Farmington River.
Ward Pond, ...	Becket, ...	16	Branch, Farmington River.
Wheeler or Ballou Reservoir, ³	Becket, ...	65	Brook, West Branch, Westfield River.
Yokum Pond, ...	Becket, ...	70	Brook, West Branch, Westfield River.
Cheshire Reservoir, ³	Cheshire 312 acres and Lanesborough 106.	418	- - -
Clarksburg Reservoir, ...	Clarksburg, ...	49	- - -
Egypt Brook Reservoir, ^{3,4}	Dalton, ...	4 ³	- - -
Harmon Pond, ...	Egremont 7 acres and Sheffield 7.	14	Branch, Hubbard Brook.
Joyners Marsh Pond, ...	Egremont, ...	25	Willards Brook.
Prospect Lake, ...	Egremont, ...	53	Green River.
North Pond, ...	Florida, ...	20	Branch, Tower Brook.
Long Pond, ...	Great Barrington, ...	109	Long Pond Brook.
Mansfield Pond, ...	Great Barrington, ...	16	Branch, Housatonic River.
Berry Pond, ...	Hancock, ...	15	Branch, Kinderhook Creek.
Ashmere Lake, ...	Hinsdale, ...	184	East Branch, Housatonic River.

¹ Surveyed.² Area taken from large scale plans or from reliable local sources.³ Wholly artificial.⁴ Used as a source of water supply.

BERKSHIRE COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Muddy Pond, ...	Hinsdale 24 acres and Washington 24.	48	Housatonic River.
Plunket Reservoir, ¹	Hinsdale, ...	74 ²	- - -
Windsor Reservoir, ...	Hinsdale 29 acres and Windsor 23.	62	East Branch, Housatonic River.
Cheshire Reservoir, ...	Lanesborough (see Cheshire).	-	- - -
Pontoosuc Lake, ...	Lanesborough 267 acres and Pittsfield 238.	505	Branch, Onota Brook.
Pond north of same, ...	Lanesborough, ...	31	- - -
Pond south of Berkshire Village.	Lanesborough, ...	15	- - -
Goose Pond, ...	Lee 100 acres and Tyringham 94.	194	Branch, Housatonic River.
Laurel Lake, ...	Lee 149 acres and Lenox 16.	165 ²	Branch, Housatonic River.
Upper Goose Pond, ...	Lee 10 acres and Tyringham 35.	46	Branch, Housatonic River.
Reservoirs (2) ^{1, 2}	Lee, ...	30 ²	- - -
Laurel Lake, ...	Lenox (see Lee), ...	-	- - -
Lower Root Reservoir, ^{1, 2}	Lenox, ...	7 ²	- - -
Lake Buel, ⁴	Monterey 100 acres and New Marlborough 36.	196 ²	Mill River.
Lake Garfield, ...	Monterey, ...	272	Mill River.
Lake Undine or Gilder Pond, ...	Mount Washington, ...	15	Undine Brook.
Plantain Pond, ...	Mount Washington, ...	58	Branch, Schenob Brook.
East Pond, ...	New Marlborough, ...	65	Branch, Mill River.
Harmon Pond, ...	New Marlborough, ...	21	- - -
Lake Buel, ⁴	New Marlborough (see Monterey).	-	- - -
Beaman Reservoir, ^{1, 2}	North Adams, ...	49 ²	- - -
Notch Brook Reservoir, ^{1, 2}	North Adams, ...	12 ²	- - -
Great Lake or Big Pond, ...	Otis, ...	310	Branch to Otis Reservoir.
Hayes Pond, ...	Otis, ...	45	Hop Brook.
Larkum Pond, ...	Otis, ...	10	Branch, Farmington River.
Otis Reservoir or Rand Pond, ...	Otis 693 acres, Blandford 2 and Tolland 370 (Hampden County).	693 ²	- - -
Parish Pond, ...	Otis, ...	48	Branch, Farmington River.
Pond at center, ...	Otis, ...	15	Farmington River.
Pond at North Otis, ...	Otis, ...	15	Farmington River.
Shaw Pond, ⁴	Otis (see Becket), ...	-	- - -
White Lily Pond, ...	Otis, ...	40	Brook to Great Lake.
Pond west of same, ...	Otis, ...	29	Brook.
Lily or Melville Pond, ...	Pittsfield, ...	10	Branch, Housatonic River.
Onota Pond, ²	Pittsfield, ...	685 ²	Onota Brook.

¹ Wholly artificial.² Area taken from large scale plans or from reliable local source.³ Used as a source of water supply.⁴ Surveyed.

BERKSHIRE COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pontecosuc Lake, . . .	Pittsfield (see Lanesborough),	-	- - -
Richmond Pond, . . .	Pittsfield 149 acres and Richmond 70.	219	- - -
Silver Lake, . . .	Pittsfield, . . .	23	Housatonic River.
Sylvan Lake or Goodrich Pond.	Pittsfield, . . .	33	Housatonic River.
Richmond Pond, . . .	Richmond (see Pittsfield),	-	- - -
Simon Pond, . . .	Sandisfield, . . .	76	Branch, Farmington River.
Spectacle Pond, . . .	Sandisfield, . . .	60	Clam River.
South Pond, . . .	Savoy, . . .	20	Gulf Brook.
Pond east of same, . . .	Savoy, . . .	28	Brook.
Harmon Pond, . . .	Sheffield (see Egremont), .	-	- - -
Mill Pond, . . .	Sheffield, . . .	80	Hubbards Brook.
Spurr Lake, . . .	Sheffield, . . .	10	Brook.
Three Mile Pond, . . .	Sheffield, . . .	12	Iron Works Brook.
Lake Agawam, . . .	Stockbridge, . . .	12	Agawam Brook.
Lake Averie or Mountain Mirror. ¹	Stockbridge, . . .	40 ²	Branch, Marsh Brook.
Mohawk Lake, . . .	Stockbridge, . . .	14	Mohawk Brook.
Stockbridge Bowl or Lake Mahkenac.	Stockbridge, . . .	377	Marsh Brook.
Goose Pond, . . .	Tyringham (see Lee), .	-	- - -
Upper Goose Pond, . . .	Tyringham (see Lee), .	-	- - -
Ashley Lake, ¹ . . .	Washington, . . .	111 ²	Ashley Brook.
Benson Pond, . . .	Washington, . . .	10	West Branch, Westfield River.
Clappe Pond, . . .	Washington, . . .	12 ²	Roaring Brook.
Farnham Reservoir, ^{1,2} .	Washington, . . .	42 ²	- - -
Muddy Pond, . . .	Washington (see Hinsdale),	-	- - -
Cranberry Pond, . . .	West Stockbridge, . . .	20	Williams River.
Crane Pond, . . .	West Stockbridge, . . .	30	Williams River.
Mud Pond, . . .	West Stockbridge, . . .	34	Williams River.
Shaker Mill Pond, . . .	West Stockbridge, . . .	65	Williams River.
Pond, . . .	Williamstown, . . .	50	Hocousac River.
Windsor Pond, . . .	Windsor, . . .	79 ²	Branch, Westfield River.
Pond in southwest corner, .	Windsor (see Hinsdale), .	-	- - -

¹ Used as a source of water supply.² Area taken from large scale plans or from reliable local sources.³ Wholly artificial.

BRISTOL COUNTY.

(Total acreage of ponds listed about 8,567.)

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Mill Pond, north of village, .	Acushnet, ...	16	Branch, Acushnet River.
New Bedford Reservoir, ^{1,2}	Acushnet, ...	411 ³	Acushnet River.
Attleboro City Pond, . .	Attleboro, ...	16	City Brook.
Dodgeville Pond, . . .	Attleboro, ...	42	Ten Mile River.
Lebanon Mills Pond, ⁴ . .	Attleboro 5 acres, Seekonk 23 and Pawtucket 19 (Rhode Island).	28 ⁵	Ten Mile River.
Ores Reservoir, ²	Attleboro, ...	43 ⁵	- - -
Pond at Hebronville, . .	Attleboro, ...	25	Ten Mile River.
Pond in southwest part, .	Attleboro, ...	15	- - -
Pond south of Robinsonville,	Attleboro, ...	10	Ten Mile River.
Robin Hollow Pond, ⁴ . .	Attleboro 12 acres and Cumberland 29 (Rhode Island).	12 ⁵	- - -
Hicksville Pond, ...	Dartmouth, ...	12	Copecut River.
Noquochoke Pond, ...	Dartmouth, ...	176	Shingle Island River.
Pond at north village, . .	Dartmouth, ...	22	Pamanset River.
Pond near Deerfield Swamp,	Dartmouth, ...	10	- - -
Pond near Freetown, . . .	Dartmouth, ...	20	Shingle Island River.
Turners Mill Pond, ⁴ . . .	Dartmouth 23 acres and New Bedford 110.	133 ⁵	Pamanset River.
Broad Cove Pond, ⁴ . . .	Dighton 71 acres and Somerset 23.	94 ⁵	Taunton River.
Mount Hope Mill Pond, ⁴ .	Dighton 8 acres and Taunton 4.	12 ⁵	Mill River.
Flyaway Pond, ...	Easton, ...	50	Quaset Brook.
Pond east of same, ...	Easton, ...	10	Quaset Brook.
Furnace Village Pond, . .	Easton, ...	11	Mulberry Brook.
Pond south of same, . . .	Easton, ...	12	Beaver Brook.
Keiths Pond, ...	Easton, ...	10	Beaver Brook.
Leaches or Wilbur Pond, ⁴ .	Easton 86 acres and Sharon 28 (Norfolk County).	86	Pecuanticlot Brook.
Long or Ames Pond, ⁴ . . .	Easton 16 acres and Stoughton 42 (Norfolk County).	16 ⁵	- - -
Lower Pond or Stone Pond,	Easton, ...	20	Quaset Brook.
Morse Pond, ...	Easton, ...	10	Quaset Brook.
Shoddy Mill Pond, ...	Easton, ...	15	Quaset Brook.
Shovel Pond, ...	Easton, ...	10	Branch to Cowesett Brook.
Stones Pond, ...	Easton, ...	20	Branch to Cowesett Brook.
Cooks Pond, ⁴	Fall River 165 acres and Tiverton 2 (Rhode Island).	165 ⁵	Brook to Mount Hope Bay.
Mill Brook Pond, ...	Fall River, ...	16	- - -
North Watuppa Pond, ^{2,4,5} .	Fall River 1,640 acres and Westport 165.	1,805 ⁵	Quequechan River.

¹ Wholly artificial.² Used as a source of water supply.³ Area taken from large scale plans or from reliable local sources.⁴ Surveyed.⁵ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

BRISTOL COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Quequechan River Mill Pond,	Fall River, ...	186	Quequechan River.
Sawdy Pond, ¹	Fall River 149 acres and Westport 225.	374 ²	Brook to Watuppa Pond.
South Watuppa Pond, ³ . .	Fall River 899 acres and Westport 652.	1,551 ²	Quequechan River.
Forges Pond, ...	Freetown, ...	50	Assonet River.
Little Quittacas Pond, ^{1,4} .	Freetown 13 acres, Lakeville 134 and Rochester 171 (Plymouth County).	13 ²	- - -
Long Pond, ...	Freetown 381 acres and Lakeville 1,381 (Plymouth County).	381	- - -
Mother Brook Pond, . .	Freetown, ...	11	- - -
Bungay Reservoir, . .	Mansfield 53 acres and North Attleborough 47.	100	Bungay River.
Fultons Pond, ...	Mansfield, ...	14	Rumford River.
Kingman and Hodges Pond,	Mansfield, ...	12	Rumford River.
Murphys Pond, ...	Mansfield, ...	10	Rumford River.
Norton Reservoir, . .	Mansfield 12 acres and Norton 496.	508	Rumford River.
Pond at Whiteville, . .	Mansfield, ...	26	Branch of Canoe River.
Robinsons Pond, . . .	Mansfield, ...	12	Wading River.
Sassaquin Pond, . . .	New Bedford, ...	39	Brook.
Turners Mill Pond, ¹ . .	New Bedford (see Dartmouth).	-	- - -
Bungay Reservoir, . .	North Attleborough (see Mansfield).	-	- - -
Falls Pond, ...	North Attleborough, .	156	Ten Mile River.
Pond east of same, . .	North Attleborough, .	18	Ten Mile River.
Pond south of center, .	North Attleborough, .	11	Ten Mile River.
Whiting Pond, ...	North Attleborough, .	23	Ten Mile River.
Barrowsville Pond, . .	Norton, ...	40	Wading River.
Pond east of same, . .	Norton, ...	12	Wading River.
Pond west of Barrowsville,	Norton, ...	38	Wading River.
Canoe Pond, ...	Norton, ...	12	Canoe River.
Norton Reservoir, . .	Norton (see Mansfield), .	-	- - -
Pond north of center, .	Norton, ...	12	Rumford River.
Winneconnet Pond, . .	Norton, ...	326	Canoe River.
Forge Pond, ...	Raynham, ...	25	Two Mile River.
Gushnee Pond, ...	Raynham, ...	47	Two Mile River.
Johnsons Pond, ¹ . . .	Raynham, ...	12 ²	- - -
Kings Pond, ...	Raynham, ...	11	Branch of Two Mile River.
Nemasket Mill Pond, ¹ .	Raynham 26 acres and Taunton 44.	70 ²	Taunton River.

¹ Surveyed.² Area taken from large scale plans or from reliable local source.³ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁴ Used as a source of water supply.

BRISTOL COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Nunkets Pond, . . .	Raynham 5 acres and Bridgewater 16 (Plymouth County).	5	- - -
Prospect Hill Pond, . . .	Raynham 18 acres and Taunton 83.	66	Pine Swamp Brook.
Smooch Mill Pond, . . .	Raynham, . . .	10	Two Mile River.
Pond in southwest part, . . .	Rehoboth, . . .	16	Palmer River.
Pond on town line, . . .	Rehoboth 2 acres and Swansea 8.	10	Rocky River.
Reservoir, . . .	Rehoboth, . . .	117	Bad Luck Brook.
Lebanon Mills Pond, ¹ . . .	Seekonk (see Attleboro), . .	-	- - -
Broad Cove Pond, ¹ . . .	Somerset (see Dighton), . .	-	- - -
Factory Pond, . . .	Swansea, . . .	10	Coles River.
Pond south of same, . . .	Swansea, . . .	21	Coles River.
Pond on town line, . . .	Swansea (see Rehoboth), . .	-	- - -
Warren Reservoir, . . .	Swansea, . . .	72	- - -
Bear Hole Pond, . . .	Taunton, . . .	33	Branch, Taunton River.
Britanniaville Pond, . . .	Taunton, . . .	18	Mill River.
Dean Factory Pond, . . .	Taunton, . . .	38	Taunton River.
Five Mile River Pond, . . .	Taunton, . . .	42	- - -
Kings Furnace Pond, . . .	Taunton, . . .	43 ²	Branch, Taunton River.
Mount Hope Mill Pond, . . .	Taunton (see Dighton), . .	-	- - -
Nemaasket Mill Pond, . . .	Taunton (see Raynham), . .	-	- - -
Oakland Pond, . . .	Taunton, . . .	23	Three Mile River.
Pond southwest of east village.	Taunton, . . .	21	Cotley River.
Prospect Hill Pond, . . .	Taunton (see Raynham), . .	-	- - -
Robinson and Kings Pond, . .	Taunton, . . .	15	Taunton River.
Sabatia Lake or Scadding Pond.	Taunton, . . .	200	Mill River.
Watsons Pond, . . .	Taunton, . . .	94	Sabatia Lake.
Devols Pond, ³ . . .	Westport, . . .	106 ²	Brook to Sawdy Pond.
North Watuppa Pond, . . .	Westport (see Fall River), . .	-	- - -
Pond west of Westport Harbor.	Westport, . . .	94	Brook to Westport Harbor.
Pond east of Peaked Rock, . .	Westport, . . .	62	Brook to Nantucket Sound.
Sawdy Pond, . . .	Westport (see Fall River), . .	-	- - -
South Watuppa Pond, . . .	Westport (see Fall River), . .	-	- - -

¹ Surveyed.² Area taken from large scale plans or from reliable local source.³ Used as a source of water supply.

DUKES COUNTY.
(Total acreage of ponds listed about 4,010.)

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Black Pond, ...	Chilmark, ...	88	Great Tisbury Pond.
Chilmark Pond, ...	Chilmark, ...	278	Black Pond.
Pond between above two, .	Chilmark, ...	20	Black Pond.
Great Tisbury Pond, ¹ . .	Chilmark 258 acres and West Tisbury 413.	671	Ocean.
Squibnocket Pond, . . .	Chilmark 360 acres and Gay Head 194.	554	- - -
Faqua Pond, ...	Edgartown, ...	20	- - -
Herring Pond, ...	Edgartown, ...	1,157	Canal.
Jobs Neck Pond, ...	Edgartown, ...	159	- - -
Oyster Pond, ...	Edgartown, ...	207	- - -
Trapp Pond, ...	Edgartown, ...	27	Songakontacket Pond.
Squibnocket Pond, . . .	Gay Head (see Chilmark),	-	- - -
Gosnold Pond, ...	Gosnold, ...	48	- - -
Nashawena Pond, ...	Gosnold, ...	25	- - -
Pond south of same, . . .	Gosnold, ...	40	- - -
Naushon Pond, ...	Gosnold, ...	70	- - -
Cottage City Reservoir, ² .	Oak Bluffs 5 acres and Tisbury 7.	12 ³	- - -
Farm Pond, ¹	Oak Bluffs, ...	24	- - -
Meadow Pond, ...	Oak Bluffs, ...	30	- - -
Chapaquasset Pond, . . .	Tisbury, ...	215	Vineyard Sound.
Cottage City Reservoir, ² .	Tisbury (see Oak Bluffs), .	-	- - -
Deep Bottom Pond, ...	West Tisbury, ...	74	Great Tisbury Pond.
Great Tisbury Pond, ¹ . .	West Tisbury (see Chilmark).	-	- - -
Homers Pond, ...	West Tisbury, ...	43	- - -
James Pond, ...	West Tisbury, ...	40	Lamberts Cove.
Pond southeast of same, .	West Tisbury, ...	10	- - -
Pond east of James, . . .	West Tisbury, ...	10	- - -
Long Cove, ...	West Tisbury, ...	91	Great Tisbury Pond.
Middle Point Creek, . . .	West Tisbury, ...	23	Great Tisbury Pond.
Watcha Pond, ...	West Tisbury, ...	74	- - -

¹ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

² Used as a source of water supply.

³ Area taken from large scale plans or from reliable local source.

ESSEX COUNTY.

(Total acreage of ponds listed about 5,351.)

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Browns Pond, . . .	Amesbury, . . .	10	- - -
Gardner Lake, . . .	Amesbury, . . .	80	- - -
Kimballs Pond or Lake Attitash.	Amesbury 275 acres and Merrimac 85.	360 ¹	Powow River.
Fosters Pond, . . .	Andover, . . .	135	Branch, Shawsheen River.
Haggetts Pond, ² . . .	Andover, . . .	198 ¹	Fish Brook.
Pomps Pond, . . .	Andover, . . .	10	Branch, Shawsheen River.
Beaver Pond, . . .	Beverly, . . .	43	Branch, Miles River.
Wenham Lake, ^{2,3} . . .	Beverly 98 acres and Wenham 153.	251 ¹	Miles River.
Cedar Pond, . . .	Boxford, . . .	12	Branch, Fish Brook.
Pond below same, . . .	Boxford, . . .	10	- - -
Chadwick Pond or Little Pond.	Boxford 8 acres and Haverhill 100.	177 ¹	Branch, Merrimack River.
Crooked Pond, . . .	Boxford, . . .	15	- - -
Four Mile Pond, . . .	Boxford, . . .	54	Fye Brook.
Hoveys Pond, . . .	Boxford, . . .	30	Brook to Johnsons Pond.
Johnsons Pond, ^{2,3,4} . . .	Boxford 78 acres and Groveland 147.	225 ¹	Branch of Merrimack River.
Perleys or Bald Pate Pond, .	Boxford, . . .	66	Penn Brook.
Spoffords Pond, . . .	Boxford, . . .	27	Fye Book.
Stiles Pond, . . .	Boxford, . . .	60	Fish Brook.
Woods Pond, . . .	Boxford, . . .	22	Fye Brook.
Pond northwest of same, .	Boxford, . . .	12	- - -
Beaver Brook Pond, . . .	Danvers, . . .	10	- - -
Pond southwest of center, .	Danvers, . . .	10	- - -
Chebacco Lake, ^{2,4} . . .	Essex 119 acres and Hamilton 90.	209 ¹	Essex River.
Pentucket Pond, ² . . .	Georgetown, . . .	40 ¹	Parker River.
Pond east of same, . . .	Georgetown, . . .	12	- - -
Rock Pond, . . .	Georgetown, . . .	57	Parker River.
Dikes Brook Reservoir, ^{2,5} .	Gloucester, . . .	58 ¹	- - -
Haskell Brook Reservoir, ^{2,5}	Gloucester, . . .	57 ¹	- - -
Ocean Pond, . . .	Gloucester, . . .	35	- - -
Wallace Reservoir, ^{2,5} . . .	Gloucester, . . .	24 ¹	- - -
Cram Pond, . . .	Groveland, . . .	22	- - -
Johnsons Pond, ² . . .	Groveland (see Boxford), .	-	- - -
Becks Pond, . . .	Hamilton, . . .	30	Brook to Round Pond.

¹ Area taken from large scale plans or from reliable local source.² Used as a source of water supply.³ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁴ Surveyed.⁵ Wholly artificial.

ESSEX COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Chebacco Lake, ¹	Hamilton (see Essex),	-	- - -
Gravelly Pond, ²	Hamilton, ...	43 ³	- - -
Pleasant Lake, ...	Hamilton 9 acres and Wenham 34.	43	Branch, Ipswich River.
Round Pond, ²	Hamilton, ...	19 ³	Brook to Chebacco Lake.
Chadwick or Little Pond, .	Haverhill (see Boxford), .	-	- - -
Crystal Lake or Creek Pond, ²	Haverhill, ...	159 ³	Creek Brook.
Kenosa Lake or Great Pond, ²	Haverhill, ...	225 ³	- - -
Lake Saltonstall or Plug Pond, ⁴	Haverhill, ...	45 ³	Branch, Merrimack River.
Millvale Reservoir, ^{2,5} . .	Haverhill, ...	103 ³	- - -
Neals Pond, ...	Haverhill 5 acres and Merrimac 5.	10	Branch, Merrimack River.
Round Pond or Pentucket Pond.	Haverhill, ...	38 ³	- - -
Dows Brook Reservoir, ^{2,5}	Ipswich, ...	18 ³	- - -
Hoods Pond, ¹	Ipswich 53 acres and Topfield 14.	67 ³	Branch, Pye Brook.
Stevens Pond, ...	Lawrence, ...	20	- - -
Birch Pond Reservoir, ² . .	Lynn 15 acres and Saugus 67.	82 ³	- - -
Breeds Pond Reservoir, ² . .	Lynn, ...	62 ³	- - -
Cedar Pond, ...	Lynn, ...	10	Stony Brook.
Glenmere Pond, ...	Lynn, ...	11	Stacy's Brook.
Hawkes Pond, ²	Lynn, ...	75 ³	- - -
Spring Pond, ²	Lynn 7 acres, Peabody 12 and Salem 30.	49 ³	- - -
Walden and Glen Lewis Pond, ²	Lynn 66 acres and Saugus 174.	240 ³	- - -
Wennehers Lake or Flax Pond.	Lynn, ...	71	Stony Brook.
Wyoma Lake or Sluice Pond,	Lynn, ...	50	Stony Brook.
Pillings Pond, ...	Lynnfield, ...	70	- - -
Santaug Lake, ²	Lynnfield 93 acres and Peabody 64.	157 ³	Noyes Brook.
Kimballs Pond or Lake Attitash.	Merrimac (see Amesbury),	-	- - -
Neals Pond, ...	Merrimac (see Haverhill),	-	- - -
Harris Pond or Youths Pond,	Methuen, ...	55	Spicket River.
Mystic Pond, ...	Methuen, ...	15	Spicket River.
Spicket River Pond, ...	Methuen, ...	30	- - -
Middleton Pond or Forest Pond, ²	Middleton, ...	95 ³	Branch, Ipswich River.
Pond near Ingalls station, .	Middleton 3 acres and North Andover 7.	10	- - -
Bear Pond, ...	Nahant, ...	12	- - -

¹ Surveyed.² Used as a source of water supply.³ Area taken from large scale plans or from reliable local source.⁴ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁵ Wholly artificial.

ESSEX COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Great Pond Reservoir, ^{1,2}	North Andover, . . .	614 ³	Chocheewick River.
Pond near Ingalls station, .	North Andover (see Middleton).	-	- - -
Bartholomew Pond Reservoir, ¹	Peabody, ...	10 ³	- - -
Browns Pond or Winona Pond, ¹	Peabody, ...	28 ³	Tapleys Brook.
Cedar Pond, ...	Peabody, ...	15	- - -
Crystal Pond, ...	Peabody, ...	14	- - -
Reservoir above pumping station, ¹	Peabody, ...	16 ³	- - -
Santaug Lake, ...	Peabody (see Lynnfield),	-	- - -
Spring Pond, ...	Peabody (see Lynn), .	-	- - -
Tapley Brook Pond, . . .	Peabody, ...	23	- - -
Cape Pond, ^{1,2}	Rockport, ...	38 ³	- - -
Spring Pond, ...	Salem (see Lynn), . .	-	- - -
Black Creek, ...	Salisbury, ...	60	- - -
Birch Pond, ...	Saugus (see Lynn), . .	-	- - -
Pond at center, ...	Saugus, ...	78	Saugus River.
Walden and Glen Lewis Pond.	Saugus (see Lynn), . .	-	- - -
Phillips Pond, ...	Swampscott, ...	14	- - -
Hoods Pond, ...	Topsfield (see Ipswich),	-	- - -
Coyo or Middle Pond, . .	Wenham, ...	35 ³	Brook to Round Pond.
Longham Reservoir, ^{1,4} .	Wenham, ...	43 ³	Miles River.
Muddy Pond, ...	Wenham, ...	18	- - -
Pleasant Lake, ...	Wenham (see Hamilton),	-	- - -
Wenham Lake, ^{1,2} . . .	Wenham (see Beverly),	-	- - -

¹ Used as a source of water supply.² Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.³ Area taken from large scale plans or from reliable local source.⁴ Wholly artificial.

FRANKLIN COUNTY.
(Total acreage of ponds listed about 1,311.)

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Great Pond, ...	Ashfield, ...	30	South River.
Glen Brook Upper (7.5 acres) and Lower Reservoir (5.7 acres). ^{1,2}	Leyden, ...	13 ³	- - -
Green Pond, ...	Montague, ...	35	- - -
Lake Pleasant, ²	Montague, ...	68	Pond Brook.
Eagleville Reservoir, ⁴ . .	New Salem 96 acres, Orange 76 and Athol 44 (Worcester County).	172 ³	Branch, Millers River.
Hacker Pond, ...	New Salem, ...	30	Brook to Thompson Pond.
Hop Brook Pond, ...	New Salem, ...	26	Brook to Neeseposset Pond.
Nance Lake, ...	New Salem, ...	26	- - -
Spectacle Ponds Nos. 1 and 2,	New Salem, ...	67	Brook to Hacker Pond.
Thompson Pond, ...	New Salem, ...	126	Brook to Neeseposset Pond.
Pond on Keyup Brook, . .	Northfield, ...	15	Keyup Brook.
Eagleville Reservoir, . .	Orange (see New Salem), .	-	- - -
North Pond Reservoir, . .	Orange, ...	132 ³	Middle Branch, Swift River.
Packard Pond, ...	Orange, ...	34	Tully River.
Stowells or Furnace Village,	Orange, ...	56	Tully River.
Locks Pond, ...	Shutesbury, ...	129	Saw Mill Brook.
Pond above Cooleyville, .	Shutesbury, ...	14	- - -
Pond near Dudleyville, .	Shutesbury, ...	12	Saw Mill Brook.
Base Reservoir, ...	Warwick, ...	25	Mill Brook.
Pond east of same, . . .	Warwick, ...	37	Orcutt Brook.
Hastings Pond, ...	Warwick, ...	17	Hodge Brook.
Pond east of same, . . .	Warwick, ...	20	Gales Brook.
Lake Moore, ...	Warwick, ...	31 ³	Moss Brook.
Pond northeast of center, .	Warwick, ...	12	Gales Brook.
Upper Pond, Tully Brook, ⁴	Warwick, ...	26 ³	Tully River.
Wicket Pond, ...	Wendell, ...	53	Wicket Brook.
Pond west of same, . . .	Wendell, ...	19	- - -
Mountain Street Reservoir. ^{1,2}	Whately, ...	75 ³	- - -

¹ Wholly artificial.² Used as a source of water supply.³ Area taken from large scale plans or from reliable local source.⁴ Surveyed.

HAMPDEN COUNTY.

(Total acreage of ponds listed about 4,106.)

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pond in southwest part,	Agawam, ...	10	Still Brook.
Blair Pond, ...	Blandford, ...	73	Pond Brook.
Borden Brook Reservoir, ^{1,2}	Blandford, ...	213 ³	- - -
Long Pond, ...	Blandford, ...	58	Pond Brook.
Otis Reservoir or Rand Pond,	Blandford 2 acres, Tolland 370 and Otis 6½ (Berk- shire County).	872 ³	- - -
Bakers Pond, ...	Brimfield, ...	10	Brook to Long Pond.
Great Pond, ...	Brimfield, ...	50	East Brook.
Little Alum Pond, ...	Brimfield, ...	60	Branch, Quinebaug River.
Pond in southwest corner, .	Brimfield, ...	14	Brook.
Black Pond, ...	Granville, ...	14	- - -
Diversion Dam Reservoir, .	Granville 5 acres and Rus- sell 5.	10 ³	- - -
Parsons Pond, ...	Granville, ...	25	Pond Brook.
Tiltonson Brook Reservoir, ^{1,2}	Granville, ...	33 ³	- - -
Scantie Pond, ...	Hampden, ...	10	- - -
Hamilton Reservoir, ...	Holland, ...	300	- - -
Holland Pond, ...	Holland, ...	68	Quinebaug River.
Ashley Reservoir, ²	Holyoke, ...	281 ³	Black Brook.
High Service Reservoir, ^{1,2}	Holyoke, ...	61 ³	- - -
Whiting Street Reservoir, ^{1,2}	Holyoke, ...	120 ³	- - -
Chapins Pond, ²	Ludlow, ...	32	- - -
Ludlow Reservoir or Spring- field Reservoir, ^{1,2}	Ludlow, ...	445 ³	- - -
Minechoag Pond, ...	Ludlow, ...	13	- - -
Pond in west part, ...	Ludlow, ...	11	- - -
Wood Pond, ...	Ludlow, ...	12	- - -
Pond east of same, ...	Ludlow, ...	15	- - -
Pond in north part, ...	Monson, ...	15	- - -
Reservoir, ^{1,2}	Montgomery, ...	33 ³	- - -
Shatterack Pond, ...	Montgomery, ...	11	Shatterack Brook.
Forest Lake, ...	Palmer, ...	62	Ware River.
Pattaquattic Pond, ...	Palmer, ...	19	Ware River.
Pond west of Thorndike, . .	Palmer, ...	14	Ware River.
Diversion Dam Reservoir, .	Russell (see Granville), .	-	- - -
Hassards Pond, ...	Russell, ...	71	Branch, Westfield River.
White Reservoir, ^{1,2}	Southampton, ...	123 ³	- - -

¹ Wholly artificial.² Used as a source of water supply.³ Area taken from large scale plans or from reliable local source.

HAMPDEN COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Congamond Lake, . . .	Southwick, . . .	530	Great Brook.
Abby Reservoir, . . .	Springfield, . . .	10	- - -
Bass Pond, . . .	Springfield, . . .	16	- - -
Brightwood Pond, . . .	Springfield, . . .	32	- - -
Dimmick Pond, . . .	Springfield, . . .	14	- - -
Five Mile Pond, ¹ . . .	Springfield, . . .	108	- - -
Pond west of same, . . .	Springfield, . . .	15	- - -
Indian Orchard Pond, . . .	Springfield, . . .	18	- - -
Lake Como, . . .	Springfield, . . .	10	- - -
Loon Pond, . . .	Springfield, . . .	29	North Branch, Mill River.
Van Horn Reservoir, . . .	Springfield, . . .	16 ²	- - -
Water Shop Pond, . . .	Springfield, . . .	200	Mill River.
Noyes Lake, . . .	Tolland, . . .	181	Pond Brook.
Otis Reservoir or Rand Pond, . . .	Tolland (see Blandford), . . .	-	- - -
Wales Pond, ³ . . .	Wales, . . .	77	- - -
Hampton Pond, . . .	Westfield 97 acres and Southampton 52 (Hampshire County).	97	- - -
Horse Pond, . . .	Westfield, . . .	34	Pond Brook.
Nine Mile Pond, . . .	Wilbraham, . . .	30	North Branch, Mill River.
Spectacle Pond, . . .	Wilbraham, . . .	16	- - -

HAMPSHIRE COUNTY.

(Total acreage of ponds listed about 1,843.)

Factory Hollow Pond, . . .	Amherst, . . .	27	- - -
Mill Valley Pond, . . .	Amherst, . . .	12	Fort River.
Pond in north village, . . .	Amherst, . . .	15	Mill River.
Broad Brook Pond, . . .	Belchertown, . . .	16	- - -
Knight and Gold Reservoir, . . .	Belchertown, . . .	36	Jabish River.
Lower Pond, . . .	Belchertown, . . .	74	Brook to Forge Pond.
Middle Pond, . . .	Belchertown, . . .	40	Brook to Forge Pond
Upper Pond, . . .	Belchertown, . . .	12	- - -
Sanford and Stebbins Pond, . . .	Belchertown, . . .	10	- - -
Damons or Burnell Pond, . . .	Chesterfield 56 acres and Goshen 32.	88 ²	Dead Branch.
Lower Mill Pond, . . .	Easthampton, . . .	39	Manhan River.

¹ Used as a source of water supply.² Area taken from large scale plans or from reliable local sources.³ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

HAMPSHIRE COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Upper Mill Pond, . . .	Easthampton, . . .	50	Manhan River.
Damons Pond, . . .	Goshen (see Chesterfield),	-	- - -
Dresser or Dadmuns Pond,	Goshen, . . .	87 ¹	The Branch.
Goshen Lower Reservoir, .	Goshen, . . .	108	Mill Brook.
Goshen Upper Reservoir, .	Goshen, . . .	71	- - -
Forge Pond, . . .	Granby, . . .	106	Bachelor Brook.
Pond north of center, . .	Granby, . . .	25	Bachelor Brook.
Stony Brook Pond, . . .	Granby, . . .	14	- - -
Curtis Pond, . . .	Greenwich, . . .	30	Branch, Middle Branch, Swift River.
Davis Pond, . . .	Greenwich, . . .	40	Branch, Middle Branch, Swift River.
East Pond, . . .	Greenwich, . . .	100	- - -
Warner Pond, . . .	Greenwich, . . .	28	- - -
Pond east of North Hadley,	Hadley, . . .	49	Mill River.
Pond north of Plainville, .	Hadley, . . .	60	Mill River.
Pond southeast of village, .	Hadley, . . .	57	Fort River.
Pond east of same, . . .	Hadley, . . .	13	- - -
Great Pond, . . .	Hatfield, . . .	20	Connecticut River.
Pond north of same, . . .	Hatfield, . . .	14	Branch, Connecticut River.
Pond in west part, . . .	Hatfield, . . .	10	Branch, Mill River.
Norwich Pond, . . .	Huntington, . . .	122 ¹	Pond Brook.
Reservoirs (Lower, 3 acres, Middle, 26 and Upper, 5). ^{2, 3}	Northampton, . . .	34 ¹	- - -
Amethyst Brook Reservoir (3).	Pelham, . . .	14.5 ¹	- - -
Pond above Pelham Road, .	Pelham 25 acres and Pres- cott 39.	64 ¹	- - -
Crooked Pond, ³ . . .	Plainfield, . . .	32.5 ¹	Brook to Windsor Lake.
Plainfield Pond, . . .	Plainfield, . . .	34	Kings Brook.
Pond above Pelham Road, .	Prescott (see Pelham), .	-	- - -
Pond east of village, . . .	South Hadley, . . .	24	- - -
Pond in north part, . . .	South Hadley, . . .	16	Stony Brook.
Hampton Pond, . . .	Southampton 52 acres and Westfield 97 (Hampden County).	52	Pond Brook.
White Pond, ^{2, 3} . . .	Southampton, . . .	128 ¹	- - -
Muddy Brook Pond, . . .	Ware, . . .	29	- - -
Hanging Mountain Reser- voir.	Westhampton, . . .	37	Branch, North Brook.
Horse Pond, . . .	Westhampton, . . .	34	- - -
Pond in south part, . . .	Westhampton, . . .	11	Sodden Brook.

¹ Area taken from large scale plans or from reliable local source.² Wholly artificial.³ Used as a source of water supply.

MIDDLESEX COUNTY.
(Total acreage of ponds listed about 11,510.)

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Grassy Pond, ...	Acton, ...	14	Long Pond Brook.
Nagog Pond, ^{1,2,3}	Acton 120 acres and Littleton 164.	284 ⁴	Nagog Brook.
South Acton Pond, ...	Acton, ...	10	- - -
Pond east of same, ...	Acton, ...	10	- - -
Lower Mystic Lake, ...	Arlington 55 acres and Medford 56.	111 ⁴	- - -
Pond southwest of same, ²	Arlington, ...	13	Mystic River.
Reservoir, ³	Arlington 19 acres and Lexington 20.	39 ⁴	- - -
Spy Pond, ...	Arlington, ...	129 ⁴	Branch, Alewife Brook.
Upper Mystic Lake, ...	Arlington 39.4 acres, Medford 39.4 and Winchester 121.	200 ⁴	Mystic River.
Ashby Reservoir, ^{2,3}	Ashby, ...	154 ⁴	Willard Brook.
Watatic Reservoir, ...	Ashby 16 acres and Ashburnham 16 (Worcester County).	16	- - -
Wrights Pond, ...	Ashby, ...	13	Pearl Hill Brook.
Ashland Reservoir, ²	Ashland, ...	169 ⁴	- - -
Hopkinton Reservoir, ²	Ashland 128 acres and Hopkinton 65.	193 ⁴	- - -
Huntington Mill Pond, ¹	Ashland 8 acres and Southboro 8 (Worcester County).	8 ⁴	- - -
Pond at center, ...	Ashland, ...	10	Sudbury River.
Pond southeast of Huntington Mill.	Ashland, ...	12	- - -
Waushakum Pond, ¹	Ashland 14 acres and Framingham 78.	92 ⁴	Steep Brook.
Bennetts Brook Pond, ...	Ayer, ...	10 ⁴	- - -
Fletcher Pond, ...	Ayer, ...	108	Nonacoicus Brook.
Long Pond, ...	Ayer 29 acres and Groton 15.	44	Nonacoicus Brook.
Plow Shop Pond, ...	Ayer, ...	27	Nonacoicus Brook.
Pond east of same, ...	Ayer, ...	62	- - -
Sandy Pond, ...	Ayer, ...	74	Nonacoicus Brook.
Spectacle Pond, ¹	Ayer 3 acres and Littleton 76.	79 ⁴	Bennetts Brook.
Farm Lake, ...	Bedford, ...	10	- - -
Birds Pond, ...	Belmont 3 acres and Cambridge 7.	10 ⁴	- - -
Little Spy Pond, ...	Belmont, ...	25 ⁴	Branch, Alewife Brook.
North Billerica Mill Pond, ...	Billerica, ...	20	- - -
Nuttings Pond, ...	Billerica, ...	67	Branch, Concord River.
Winnings Pond, ...	Billerica, ...	10	Branch, Concord River.
Withingtons Pond, ...	Boxborough, ...	37	Assabet Brook.

¹ Surveyed.² Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.³ Used as a source of water supply.⁴ Area taken from large scale plans or from reliable local source.⁵ Wholly artificial.

MIDDLESEX COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pond near Lexington line, . . .	Burlington, ...	10	Vine Brook.
Pond in south part, . . .	Burlington, ...	12	- - -
Birds Pond, ...	Cambridge (see Belmont),	-	- - -
Fresh Pond, ¹	Cambridge, ...	151 ²	Alewife Brook.
Hart Pond, ...	Chelmsford, ...	67	Meadow Brook.
Newfield Pond, ...	Chelmsford, ...	77	Canal to Stony Brook.
West Chelmsford Mill Pond,	Chelmsford 14 acres and	20	- - -
Damons Pond, ...	Westford 6.	24	- - -
Damons Pond, ...	Concord, ...	10	- - -
Fairhaven Bay, ...	Concord 50 acres and Lin-	66	Sudbury River.
Lake Walden, ³	coln 16.	65 ²	- - -
West Concord Pond, . . .	Concord, ...	72	- - -
White Pond, ...	Concord, ...	40	- - -
Beaver River Mill Pond, .	Dracut, ...	10	- - -
Long Pond, ...	Dracut 68 acres and Pelham	68	Double Brook.
Merrimac Mills Pond, . .	45 (New Hampshire). .	12	Merrimack River.
Peters Pond, ...	Dracut, ...	77	Bartletts Brook.
Tyngs Pond, ⁴	Dracut 20 acres and Tyngs-	209	Branch, Lawrence Brook.
Lower Massapoag Pond, .	borough 189.	24	Salmon Brook.
Massapoag Pond, ⁵ . . .	Dunstable, ...	144 ²	- - -
Farm Pond, ¹	Dunstable 51 acres, Groton	165 ²	Sudbury River.
Framingham Reservoir No.	40 and Tyngsborough 53.	154 ²	- - -
1, 1, 1, ⁵	Framingham, ...	134 ²	- - -
Framingham Reservoir No.	Framingham, ...	250 ²	- - -
2, 1, 1, ⁵	Framingham, ...	12	Steep Brook.
Framingham Reservoir No.	Framingham, ...	730 ²	Cochituate Brook.
3, 1, 1, ⁵	Gleason Pond, ...	45	- - -
Lake Cochituate, ...	Framingham 93 acres, Na-	10	- - -
Learns Pond, ...	tucket 527.5 and Wayland	21	- - -
Pickeral Pond, ...	109.5.	10	- - -
Saxonville Pond, ...	Framingham, ...	10	- - -
Sucker Pond, ...	Framingham, ...	-	- - -
Wauashakum Pond, ³ . .	Framingham (see Ash-	78	Baddacook Brook.
Baddacook Pond, ⁴ . . .	land).	11	- - -
Cow Pond, ...	Groton, ...	-	- - -
	Groton, ...	-	- - -

¹ Used as a source of water supply.² Area taken from large scale plans or from reliable local source.³ Surveyed.⁴ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁵ Wholly artificial.

MIDDLESEX COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Duck Pond, ...	Groton, ...	52	- - -
Forge Pond, ¹	Groton 0.1 acre, Littleton 76 and Westford 136.	212 ²	Stony Brook.
Knops Pond, ...	Groton, ...	62	Branch, Martins Pond Brook.
Long Pond, ...	Groton (see Ayer), . . .	-	- - -
Martins Pond, ...	Groton, ...	23	Martins Pond Brook.
Massapoag Pond, ...	Groton (see Dunstable), . .	-	- - -
Factory Pond, ...	Holliston, ...	16	- - -
Lake Winthrop, ³	Holliston, ...	83	Jar Brook.
Pond in east village, ...	Holliston, ...	26	Jar Brook.
Echo Lake, ...	Hopkinton, ...	73 ²	- - -
Hopkinton Reservoir, ^{4,5}	Hopkinton (see Ashland), . .	-	- - -
North Pond, ¹	Hopkinton 226 acres and Milford 8 (Worcester County).	226 ²	Mill River.
Pond near Southville, ...	Hopkinton 5 acres and Southborough 6 (Worcester County).	5	- - -
Whitehall Reservoir, ⁶	Hopkinton, ...	601 ²	Sudbury River.
Boon Pond, ...	Hudson 5 acres and Stow 104.	109	Assabet River.
Pond at center, ...	Hudson, ...	21	- - -
Pond west of center, ...	Hudson, ...	20	- - -
White Pond, ⁶	Hudson 25 acres and Stow 33.5.	58.5 ²	Assabet River.
Arlington Reservoir, ...	Lexington (see Arlington), . .	-	- - -
Upper Hobbs Brook Reservoir, ^{4,5}	Lexington 67 acres, Lincoln 15 and Waltham 10.	92 ²	- - -
Beaver Pond, ...	Lincoln, ...	112 ²	Branch, Stony Brook.
Fairhaven Bay, ...	Lincoln (see Concord), . .	-	- - -
Lower Hobbs Brook Reservoir, ^{4,5}	Lincoln 50 acres and Waltham 417.	467 ²	- - -
Sandy Pond, ^{2,5}	Lincoln, ...	154 ²	Stony Brook.
Upper Hobbs Brook Reservoir, ⁵	Lincoln (see Lexington), . .	-	- - -
Forge Pond, ¹	Littleton (see Groton), . .	-	- - -
Fort Pond, ...	Littleton, ...	85	- - -
Long Pond, ...	Littleton, ...	88	- - -
Mill Pond, ...	Littleton, ...	75	- - -
Nagog Pond, ^{1,2,5}	Littleton (see Acton), . .	-	- - -
Spectacle Pond, ¹	Littleton (see Ayer), . .	-	- - -
Fort Meadow Reservoir, ...	Marlborough, ...	307 ²	Fort Meadow Brook.

¹ Surveyed.² Area taken from large scale plans or from reliable local sources.³ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁴ Wholly artificial.⁵ Used as a source of water supply.

MIDDLESEX COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Millham Reservoir, ^{1,2}	Marlborough, ...	67 ³	- - -
Sudbury Reservoir, ²	Marlborough 292 acres and Southborough 1,000 (Worcester County).	292 ³	- - -
Williams Reservoir, ²	Marlborough, ...	73 ³	Millham Brook.
Assabet Mill Pond, . . .	Maynard, ...	24	Assabet River.
Puffers Pond, ...	Maynard 24 acres and Sudbury 6.	30	Assabet River.
Middle Reservoir, ^{1,2} . .	Medford 12 acres and Stoneham 46.	58 ³	- - -
Mystic Lakes, ...	Medford (see Arlington), .	-	- - -
South Reservoir, ^{1,2} . .	Medford, ...	82 ³	- - -
Crystal Lake or Ell Pond, .	Melroe, ...	27	Malden River.
Dug Pond, ...	Natick, ...	52	- - -
Jennings Pond, ...	Natick, ...	10	Brook to Moses Pond.
Lake Cochituate, ...	Natick (see Framingham), .	-	- - -
Moses Pond, ⁴	Natick 6 acres and Wellesley 110 (Norfolk County).	6 ³	- - -
None Such Pond, ⁴ . . .	Natick 29 acres and Weston 11.	40 ³	Brook to Moses Pond.
Pond on Steep Brook, . .	Natick, ...	10	Brook to Lake Cochituate.
Reservoir Pond, ...	Natick, ...	58	Brook to Lake Cochituate.
Needham Reservoir, . . .	Needham, ...	15	- - -
Sabrina Lake, ...	Needham, ...	23	- - -
Boston Manufacturing Company's Pond.	Newton, Waltham and Weston.	280	- - -
Crystal Lake or Wiswall's Pond, ⁵	Newton, ...	41 ³	- - -
Hammond Pond, ...	Newton, ...	17	Branch, Charles River.
Pond south of Morseville, .	Newton, ...	21	- - -
Silver Lake, ...	Newton, ...	10	- - -
Martins Pond, ...	North Reading, ...	100	Martins Brook.
Pond on Ipswich Line, ⁴ .	North Reading, ...	13 ³	- - -
Swan Pond, ...	North Reading, ...	45	Branch, Ipswich River.
Healds Pond, ...	Pepperell, ...	10	- - -
Farm Pond, ...	Sherborn, ...	124 ³	Branch, Charles River.
Double Pond south of village,	Shirley, ...	13	- - -
Paper Mill Pond, ...	Shirley, ...	20	Squannacook River.
Pond below dam, ...	Shirley, ...	10	- - -
Pond northwest of village, .	Shirley, ...	42	- - -

¹ Wholly artificial.² Used as a source of water supply.³ Area taken from large scale plans or from reliable local source.⁴ Surveyed.⁵ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

MIDDLESEX COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Doleful Pond, . . .	Stoneham, . . .	10	Malden River.
Fells Reservoir, . . .	Stoneham, . . .	8.5	- - -
Middle Reservoir, ¹ . . .	Stoneham (see Medford), .	-	- - -
North Reservoir, ^{1,2} . . .	Stoneham 31 acres and Winchester 28.	59 ³	- - -
Spot Pond, ^{1,4} . . .	Stoneham, . . .	309 ⁵	Malden River.
Boon Pond, . . .	Stow (see Hudson), . . .	-	- - -
White Pond, . . .	Stow (see Hudson), . . .	-	- - -
Puffers Pond, . . .	Sudbury (see Maynard), .	-	- - -
Willis Pond, . . .	Sudbury, . . .	26	Run Brook.
Long Pond, . . .	Tewksbury, . . .	64	Content Brook.
Round Pond, . . .	Tewksbury, . . .	15	Strongwater Brook.
Bixbys Reservoir, . . .	Townsend, . . .	10	Branch, Squannacook River.
Harbor Pond, . . .	Townsend, . . .	51	Squannacook River.
Witch Brook Reservoir, ¹ .	Townsend, . . .	15	Squannacook River.
Locust Pond, . . .	Tyngsborough, . . .	18	- - -
Massapog Pond, . . .	Tyngsborough (see Dunstable).	-	- - -
Park Pond, . . .	Tyngsborough, . . .	38	- - -
Tyngs Pond, ⁴ . . .	Tyngsborough (see Dracut).	-	- - -
Crystal Lake, ^{1,4} . . .	Wakefield, . . .	83 ⁵	Saugus River.
Lake Quannapowitt, ^{4,5} .	Wakefield, . . .	254 ⁵	Saugus River.
Boston Manufacturing Company's Pond.	Waltham (see Newton), .	-	- - -
Hardys or Means Pond, . .	Waltham, . . .	47	Beaver Brook.
Lower Hobbs Reservoir, . .	Waltham (see Lincoln), .	-	- - -
Stony Brook Reservoir, ^{1,2} .	Waltham 36 acres and Weston 35.	72 ³	- - -
Upper Hobbs Reservoir, . .	Waltham (see Lexington),	-	- - -
Baldwins Pond, . . .	Wayland, . . .	10	- - -
Dudleys Pond, . . .	Wayland, . . .	75	- - -
Heards Pond, . . .	Wayland, . . .	83 ⁵	Sudbury River.
Lake Cochituate, . . .	Wayland (see Framingham).	-	- - -
Snake Brook Reservoir, ^{1,2} .	Wayland, . . .	12	- - -
Brookside Pond, . . .	Westford, . . .	11	- - -
Burgess Pond, . . .	Westford, . . .	22	Branch, Keyes Brook.
Flushing Pond, . . .	Westford, . . .	16	Brook to Nabnasset-Pond.

¹ Used as a source of water supply.² Wholly artificial.³ Area taken from large scale plans or from reliable local source.⁴ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁵ Surveyed.

MIDDLESEX COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Forge Pond, ...	Westford (see Groton), .	-	- - -
Keyes Pond, ...	Westford, ...	50	Keyes Brook.
Nabnasset Pond, ...	Westford, ...	115	Branch, Stony Brook.
Pond east of center, ...	Westford, ...	10	- - -
Sought For Pond, ...	Westford, ...	95	Branch, Spaulding Brook.
West Chelmsford Mill Pond,	Westford (see Chelmsford),	-	- - -
Boston Manufacturing Company's Pond,	Weston (see Newton), .	-	- - -
None Such Pond, ...	Weston (see Natick), .	-	- - -
Stony Brook Reservoir, ...	Weston (see Waltham), .	-	- - -
Weston Reservoir, ¹	Weston, ...	60 ²	- - -
Silver Lake, ...	Wilmington, ...	15	Lubber Brook.
Pond northwest of same, ...	Wilmington, ...	10	- - -
Aberjona Pond, ...	Winchester, ...	17	- - -
Judkins Pond, ...	Winchester, ...	19 ²	- - -
Mystic Lakes, ...	Winchester (see Arlington),	-	- - -
North Reservoir, ...	Winchester (see Stoneham),	-	- - -
Wedge Pond, ...	Winchester, ...	28 ²	Mystic River.
Winter Pond, ...	Winchester, ...	20	- - -
Burbank Pond, ...	Woburn, ...	12	Aberjona River.
Horn Pond, ¹	Woburn, ...	102 ²	Mystic River.
Richardsons Mill Pond, ...	Woburn, ...	30	Mystic River.

NANTUCKET COUNTY.

(Total acreage of ponds listed about 815.)

Gibbs Pond, ...	Nantucket, ...	38	- - -
Hammoek Pond, ...	Nantucket, ...	257	- - -
Long Pond, ...	Nantucket, ...	183	- - -
Miacomet Pond, ...	Nantucket, ...	44	- - -
Sachacha Pond, ...	Nantucket, ...	293	- - -

¹ Used as a source of water supply.² Area taken from large scale plans or from reliable local source.

NORFOLK COUNTY.

(Total acreage of ponds listed about 4,419.)

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Salisbury Brook Reservoir, ^{1,2}	Avon, ...	92.5 ³	- - -
Beaver Pond, ...	Bellingham, ...	38	Charles River.
Factory Pond, ⁴	Bellingham 14 acres and Hopdale 14 (Worcester County).	14 ³	- - -
Jencks Reservoir, . . .	Bellingham, ...	12	Peters River.
Pond north of center, . .	Bellingham, ...	14	Charles River.
Pond west of center, . .	Bellingham, ...	24	Charles River.
Pond in North Bellingham, .	Bellingham, ...	18	Charles River.
Pond south of North Bellingham.	Bellingham, ...	21	Charles River.
Cranberry Pond, ...	Braintree, ...	32	Cranberry Brook.
Great Pond, ^{3,4}	Braintree 161 acres and Randolph 43.	204 ³	Brook to Fore River.
Group east of railroad, .	Braintree, ...	17	- - -
Little Pond Reservoir, ³ .	Braintree, ...	72 ³	- - -
Pond west of same, . . .	Braintree, ...	54	- - -
Brookline Reservoir, . .	Brookline, ...	115 ³	- - -
Ames Pond, ...	Canton, ...	12	Pequid Brook.
Bolivar Pond, ...	Canton, ...	17	- - -
Factory Pond, ...	Canton, ...	13	- - -
Forge Pond, ...	Canton, ...	24	Pequid Brook.
Glen Echo Lake or York Pond. ⁴	Canton 11 acres and Stoughton 6.	17 ³	Beaver Brook.
Ice Pond, ...	Canton, ...	10	- - -
Ponkapog Pond, ⁴	Canton 98 acres and Randolph 111.	209 ³	- - -
Reservoir Pond, ...	Canton, ...	225	- - -
Scituate Pond or Lily Pond,	Cohasset, ...	48	- - -
Straights Pond, ...	Cohasset 44 acres and Hull 64 (Plymouth County).	44	- - -
The Gulf, ...	Cohasset 35 acres and Scituate 49 (Plymouth County).	85	- - -
Wigwam Pond, ...	Dedham, ...	30	Branch, Charles River.
Cocasset Pond, ...	Foxborough, ...	38	Cocasset River.
Pond south of same, . . .	Foxborough, ...	20	Cocasset River.
Reservoir northwest of Cocasset.	Foxborough, ...	20	Cocasset River.
Miramichi Pond or Shepards Pond. ⁴	Foxborough 44 acres and Plainville 129.	173 ³	Wading River.
Neponset Reservoir, . . .	Foxborough, ...	438 ³	Neponset River.
Pond at town line, . . .	Foxborough 12 acres and Sharon 1.	13	- - -
Pond at South Walpole, . .	Foxborough 5 acres and Walpole 5.	10	Brook to Neponset Reservoir.

¹ Wholly artificial.² Used as a source of water supply.³ Area taken from large scale plans or from reliable local source.⁴ Surveyed.

NORFOLK COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Witch Pond, ¹	Foxborough 12 acres and Mansfield 0.2 (Bristol County).	12 ²	- - -
Beaver Pond, ³	Franklin, ...	36	Mine Brook.
Dr. Millers Reservoir, . .	Franklin, ...	21	Mill River.
Electric Light Plant Pond, ¹	Franklin 7.5 acres and Medway 7.5.	15 ²	- - -
Mill Pond, ¹	Franklin 6 acres and Medway 6.	12 ²	- - -
Pond in northeast part, .	Franklin, ...	25	- - -
Uncas Pond, ...	Franklin, ...	27	Brook to Whiting Pond.
Unionville Pond, ...	Franklin, ...	31	- - -
Pond in west part, . . .	Holbrook, ...	11	- - -
Electric Light Plant, . .	Medway (see Franklin), .	-	- - -
Mill Pond, ...	Medway (see Franklin), .	-	- - -
Boggastow Pond, ...	Millis, ...	14 ²	Boggastow Brook.
Houghton Pond, ...	Milton, ...	28	Blue Hill River.
Popes Pond, ...	Milton, ...	15	- - -
Turners Pond, ...	Milton, ...	14	- - -
Pond near center, . . .	Needham, ...	10	Rosemary Brook.
Reservoir near center, .	Needham, ...	15	Charles River.
Sabrina Lake, ...	Needham 15 acres and Wellesley 8.	23	- - -
City Mills Pond, ...	Norfolk, ...	16	Mill River.
Pond south of same, . .	Norfolk, ...	19	- - -
Highland Lake, ...	Norfolk, ...	14	- - -
Kingsbury Pond, ...	Norfolk, ...	20	- - -
Marsh Pond, ^{1,3}	Norfolk 7 acres and Wrentham 56.	63 ²	- - -
Pond south of center, . .	Norfolk, ...	10	Stony Brook.
Populatic Pond, ...	Norfolk, ...	48	Charles River.
Ellis Pond, ³	Norwood, ...	19	Brook to Neponset River.
Willet's Pond, ^{2,4} . . .	Norwood 21 acres, Walpole 174 and Westwood 15.	210 ²	Brook to Neponset River.
Miramichi Pond or Shepards Pond, ¹	Plainville (see Foxborough).	-	- - -
Shepardville Reservoir, .	Plainville, ...	176	Wading River.
Great Pond, ...	Randolph (see Braintree), .	-	- - -
Ponkapoag Pond, ...	Randolph (see Canton), .	-	- - -
Billings Pond or Wolomolo-poag Pond.	Sharon, ...	35	Rumford River.
Group of 3 mill ponds, .	Sharon, ...	22	- - -

¹ Surveyed.² Area taken from large scale plans or from reliable local source.³ Used as a source of water supply.⁴ Wholly artificial.

NORFOLK COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Leaches Reservoir or Wilbur Pond. ¹	Sharon 28 acres and Easton 86 (Bristol County).	28 ¹	- - -
Pond at town line, . . .	Sharon (see Foxborough), .	-	- - -
Glen Echo Lake or York Pond.	Stoughton (see Canton), .	-	- - -
Long or Ames Pond, . . .	Stoughton 42 acres and Easton 16 (Bristol County).	42 ²	Quaset Brook.
Ponds west of center (group),	Stoughton, . . .	39	- - -
Birds Pond, ...	Walpole, ...	29	Neponset River.
Diamond Pond or Sawmill Pond.	Walpole, ...	15	Neponset River.
Mill Pond, ...	Walpole, ...	21	Neponset River.
Mill Pond, ...	Walpole, ...	22	Neponset River.
Morey's Pond, ...	Walpole, ...	15	Neponset River.
Plympton Pond, ...	Walpole, ...	16	- - -
Pond at South Walpole, .	Walpole (see Foxborough),	-	- - -
Willetts Pond, ...	Walpole (see Norwood), .	-	- - -
Lake Waban, ...	Wellesley, ...	185	Waban Brook.
Morses Pond, ^{1,3}	Wellesley 110 acres and Natick 6 (Middlesex County).	110 ⁴	Brook to Lake Waban.
Sabrina Lake, ...	Wellesley (see Needham),	-	- - -
Buckmaster Pond, ^{3,4} . . .	Westwood, ...	30 ⁴	Hawes Brook.
Willetts Pond, ^{4,5}	Westwood (see Norwood),	-	- - -
Great Pond, ⁴	Weymouth, ...	290	Mill River.
Whitmans Pond, ...	Weymouth, ...	188	Weymouth Back River.
Archers Pond, ...	Wrentham, ...	82	- - -
Lake Pearl or Whittings Pond,	Wrentham, ...	273	Mill River.
Marsh Pond, ...	Wrentham (see Norfolk), .	-	Stony Brook.

¹ Surveyed.² Area taken from large scale plans or from reliable local source.³ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁴ Used as a source of water supply.⁵ Wholly artificial.

PLYMOUTH COUNTY.

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Island Grove Pond, . . .	Abington, ...	38	Shumatuscancant River.
Poole's Box Factory Pond, . .	Abington, ...	10	- - -
Pond south of same, . . .	Abington, ...	22	- - -
Whitman Reservoir or Hobart Pond, . . .	Abington 20 acres and Whitman 187.	207	Bear Meadow Brook.
Carvers Pond, ...	Bridgewater, ...	20	South Brook.
Nipponick Pond, ...	Bridgewater, ...	348 ¹	Town River.
Nunkets Pond, ...	Bridgewater 16 acres and Raynham 5 (Bristol County).	16	Taunton River.
Wheeler or Cross Pond, . . .	Brockton, ...	25	Salisbury Plain River.
Bartlett's Pond, ...	Carver, ...	14	Sampeons Brook.
Bates Pond, ...	Carver, ...	20	- - -
Chases Bog, ...	Carver, ...	14	- - -
Clear Pond, ²	Carver, ...	10 ¹	- - -
Coopers Pond, ²	Carver, ...	16	- - -
Dunham Pond, ²	Carver, ...	45	Sampeons Brook.
East Head Pond, ...	Carver 58 acres and Plymouth 47.	103 ¹	Wankinco River.
Factory Pond, ...	Carver, ...	36	Sampeons Brook.
Federal Furnace Pond, . . .	Carver 86 acres and Plymouth 52.	138	Sampeons Brook.
Horse Neck Pond, ...	Carver, ...	50	- - -
Johns Pond, ²	Carver, ...	28	Green Brook.
Sampeons Pond, ²	Carver, ...	310	Sampeons Brook.
South Meadow Pond, ...	Carver, ...	17	- - -
Pond south of same, ...	Carver, ...	14	- - -
Vaughns Pond, ²	Carver, ...	15	Beaver Dam Brook.
Wenham Pond, ²	Carver, ...	50	Herring Brook.
Chandler's Pond, ...	Duxbury 20 acres and Pembroke 20.	40	Pine Brook.
Island Creek Pond, ²	Duxbury, ...	72	Island Creek.
Pond in northwest part, . .	Duxbury, ...	10	Branch, South River.
Round Pond, ...	Duxbury, ...	11	Brook.
Pond in northwest part, . .	East Bridgewater, . . .	12	Beaver Brook.
Robbins Pond, ...	East Bridgewater, . . .	158	Satucket River.
Upper Pond, ...	East Bridgewater, . . .	10	Meadow Brook.
Monponsett Pond, ^{2,3}	Halifax 735 acres and Hanson 21.	756 ¹	Satucket River.
Pond south of same, ...	Halifax, ...	12	Winetuxet River.

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PLYMOUTH COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Muddy Pond, ¹	Halifax 10 acres and Pembroke 5.	15	- - -
Pond in southwest part,	Halifax,	10	Winetuxet River.
Clapp Rubber Company Mill Pond, ²	Hanover 9.5 acres and Pembroke 9.5.	19 ²	- - -
E. Phillips & Sons Pond, ²	Hanover 35 acres and Hanson 13.	48 ²	- - -
Phillips Tack Factory Pond, ²	Hanover 5 acres and Hanson 5.	10 ²	- - -
Pond south of West Hanover,	Hanover,	17	Indian Head River.
Watermans Tack Factory Pond, ²	Hanover 10 acres, Hanson 2 and Pembroke 8.	20 ²	- - -
Cushing Pond,	Hanson,	40	- - -
Pond southwest of same,	Hanson,	30	- - -
Indian Head Pond, ^{1,2}	Hanson,	126 ²	Indian Head Brook.
Maquan Pond, ¹	Hanson,	45 ²	Brook to Indian Head Pond.
Monponsett Pond, ¹	Hanson (see Halifax),	-	- - -
Oldham Pond,	Hanson 46 acres and Pembroke 186.	232 ²	Herring Brook.
E. Phillips & Sons Pond,	Hanson (see Hanover),	-	- - -
Phillips Tack Factory Pond,	Hanson (see Hanover),	-	- - -
Wampetuck Pond,	Hanson,	81 ²	Indian Head Brook.
Watermans (as above),	Hanson (see Hanover),	-	- - -
Accord Pond, ^{2,4}	Hingham 48 acres, Norwell 26 and Rockland 26.	100 ²	Weir River.
Cushing Pond,	Hingham,	12	Branch, Weir River.
Triphammer Pond,	Hingham,	14	Branch, Weir River.
Straights Pond,	Hull 64 acres and Cohasset 44 (Norfolk County).	64 ²	- - -
Blackwater Pond,	Kingston,	14	Pine Brook.
Crossmans Pond,	Kingston,	15	Pine Brook.
Furnace Brook Ponds,	Kingston,	19	- - -
Great Indian Pond, ¹	Kingston 58 acres and Plympton 4.	62 ²	- - -
Muddy Pond,	Kingston,	37	- - -
Pine Brook Pond,	Kingston,	10	- - -
Silver Lake, ⁴	Kingston 90 acres, Pembroke 431 and Plympton 123.	644 ²	Jones River.
Smelt Pond,	Kingston,	44	Smelt Brook.
Assawompeett Pond including Pockaha Pond, ^{1,2,4}	Lakeville 1,965 acres and Middleborough 691.	2,656 ²	Nemaaket River.
Clear Pond,	Lakeville,	28	- - -
Dunhams Pond,	Lakeville,	10	- - -
Elder Pond Reservoir, ^{1,4}	Lakeville,	145 ²	Brook.

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PLYMOUTH COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Great Quittacas Pond, ^{1,2,3}	Lakeville 416 acres, Rochester 304 and Middleborough 408.	1,128 ⁴	Connects with Pocksha Pond.
Little Quittacas Pond, ^{2,3}	Lakeville 134 acres, Rochester 171 and Freetown 13 (Bristol County).	305 ⁴	Connects with Great Quittacas Pond.
Long Pond, ²	Lakeville 1,361 acres and Freetown 381 (Bristol County).	1,361 ⁴	Connects with Assawompeett Pond.
Loon Pond,	Lakeville,	30	- - -
Pocksha Pond, ^{1,2}	Lakeville (see Assawompeett Pond).	-	Connects with Assawompeett Pond.
Mary's Pond, ²	Marion 3 acres and Rochester 78.	81	Branch, Sippican River.
Pond near Lawrence Swamp,	Marion,	12	Mill Creek.
Pond south of South Village,	Marshfield,	14	South River.
Pond near Acushnet line,	Mattapoisett,	12	Mattapoisett River.
Assawompeett Pond, ²	Middleborough (see Lakeville.)	-	Namasket River.
Benaons Pond, ¹	Middleborough,	29 ⁴	Branch, Weweantic River.
Great Quittacas Pond, ^{1,2}	Middleborough (see Lakeville.)	-	Connects with Pocksha Pond.
Little Quittacas Pond, ²	Middleborough (see Lakeville.)	-	Connects with Great Quittacas Pond.
Pocksha Pond, ²	Middleborough (see Lakeville.)	-	Connects with Assawompeett Pond.
Rock Station Pond,	Middleborough,	10	- - -
Tispaquin Pond, ¹	Middleborough,	250 ⁴	Fall Brook.
Waterville Pond,	Middleborough,	29	Whetstone Brook.
Woods Pond,	Middleborough,	41	Woods Brook.
Accord Pond, ²	Norwell (see Hingham),	-	- - -
Black Pond,	Norwell,	48	Second Herring Brook.
Bound Brook Pond,	Norwell,	12	- - -
Jacobs Pond,	Norwell,	54 ⁴	Third Herring Brook.
Torreys Pond,	Norwell,	10	- - -
Chandlers Pond,	Pembroke (see Duxbury),	-	- - -
Clapp Rubber Company Mill Pond.	Pembroke (see Hanover),	-	- - -
Furnace Pond, ²	Pembroke,	103	Herring Brook.
Great Sandy Bottom Pond, ²	Pembroke,	113 ⁴	Herring Brook.
Hobomack Pond,	Pembroke,	15	- - -
Indian Head Pond,	Pembroke (see Hanson),	-	- - -
Little Sandy Bottom Pond, ²	Pembroke,	61	Brook to Great Sandy Bottom Pond.
Muddy Pond, ²	Pembroke (see Halifax),	-	- - -
Oldham Pond, ²	Pembroke (see Hanson),	-	- - -

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PLYMOUTH COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pond north of centre, . . .	Pembroke, . . .	11	Herring River.
Silver Lake, ...	Pembroke (see Kingston),	-	- - -
Stetsons Pond, ¹	Pembroke, ...	93	Brook to Monponsett Pond.
Bartlett Pond, ...	Plymouth, ...	71	- - -
Bartletts Pond, ...	Plymouth, ...	14	- - -
Beaver Dam Pond, . . .	Plymouth, ...	194	Beaver Dam Brook.
Billington Ice Pond, ¹ . .	Plymouth, ...	269	- - -
Bloody Pond, ¹	Plymouth, ...	115	- - -
Boat Pond, ²	Plymouth, ...	45	- - -
Bumps Pond, ...	Plymouth, ...	20	- - -
Charge Pond, ¹	Plymouth, ...	45	- - -
Clam Pudding Pond, . .	Plymouth, ...	10	- - -
Clear Pond, ¹	Plymouth, ...	12	- - -
Clew Pond, ...	Plymouth, ...	44	- - -
Cooks Pond, ¹	Plymouth, ...	28	- - -
Cottage Pond, ...	Plymouth, ...	40	- - -
Darby Pond, ¹	Plymouth, ...	87	- - -
Dunhams Pond, ...	Plymouth, ...	12	- - -
East Head Pond, ...	Plymouth (see Carver),	-	- - -
Eel Run Pond, ...	Plymouth, ...	19	- - -
Elbow Pond, ...	Plymouth, ...	16	- - -
Ellis Pond, ...	Plymouth, ...	11	- - -
Esekiels Pond, ...	Plymouth, ...	26	- - -
Fawn Pond, ¹	Plymouth, ...	20	- - -
Fearings Pond, ...	Plymouth, ...	40	- - -
Federal Furnace Pond, .	Plymouth (see Carver),	-	- - -
Five Mile Pond, ^{1,3} . . .	Plymouth, ...	23 ⁴	- - -
Fresh Pond, ¹	Plymouth, ...	62	- - -
Gallows Pond, ...	Plymouth, ...	37	- - -
Pond north of same, . .	Plymouth, ...	27	- - -
Grassy Pond, ...	Plymouth, ...	12	- - -
Great Herring Pond, ³ . .	Plymouth 376 acres and Bourne 2 (Barnstable County).	376 ⁴	- - -

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² Used as a source of water supply.

³ Surveyed.

⁴ Area taken from large scale plans or from reliable local source.

PLYMOUTH COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Great South Pond, ^{1,2}	Plymouth,	303 ³	Eel River.
Gunners Exchange Pond, ¹	Plymouth,	45	- - -
Half-way Pond, ¹	Plymouth,	232	Agawam River.
Island Pond, ¹	Plymouth,	68	- - -
Jenkins Pond,	Plymouth,	15	- - -
Kings Pond,	Plymouth,	12	- - -
Little Herring Pond,	Plymouth,	74	Brook to Great Herring Pond.
Little Island Pond,	Plymouth,	15	Brook to Beaver Dam Pond.
Little Long Pond, ¹	Plymouth,	45	Brook to Long Pond.
Little Pond,	Plymouth,	45	- - -
Little Sandy Pond,	Plymouth,	11	- - -
Little South Pond, ²	Plymouth,	70 ³	Brook to Great South Pond.
Long Pond near Half-way Pond.	Plymouth,	215	- - -
Long Pond near Three Cornered Pond.	Plymouth,	23	- - -
Long Pond near Wareham line.	Plymouth,	11	- - -
Lout Pond, ²	Plymouth,	18	- - -
Micajahs Pond,	Plymouth,	10	- - -
Mill Pond,	Plymouth,	40	- - -
Muddy Pond,	Plymouth,	12	- - -
North Triangle Pond,	Plymouth,	10	- - -
Old Colony Duck Pond,	Plymouth,	12	Eel River.
Rocky Pond,	Plymouth,	34	- - -
Rocky Pond,	Plymouth,	15	- - -
Russells Mill Pond,	Plymouth,	52	Eel River.
Salt Pond,	Plymouth,	35	- - -
Sandy Pond,	Plymouth,	58	- - -
Saverys Pond,	Plymouth,	20	- - -
Ship Pond,	Plymouth,	16	- - -
South Triangle Pond,	Plymouth,	15	- - -
Three Cornered Pond,	Plymouth,	20	- - -
Triangle Pond,	Plymouth,	25	- - -
West Pond,	Plymouth,	75	- - -
White Island Pond,	Plymouth 335 acres and Wareham 73.	408 ³	Red Brook.
Wiggins Pond,	Plymouth,	21	Red Brook.

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PLYMOUTH COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pond northwest of same, ...	Plymouth, ...	12	- - -
Great Indian Pond, ¹	Plympton (see Kingston), ...	-	- - -
Pond in south corner, ...	Plympton, ...	10	Whetstone Brook.
Pond north of center, ...	Plympton, ...	13	- - -
Ridge Hill Pond, ...	Plympton, ...	13	- - -
Silver Lake, ...	Plympton (see Kingston), ...	-	- - -
Great Quittacas Pond, ...	Rochester (see Lakeville), ...	-	- - -
Hathaways Pond, ...	Rochester, ...	34	Sippican River.
Leonards Pond, ...	Rochester, ...	31	Sippican River.
Little Quittacas Pond, ...	Rochester (see Lakeville), ...	-	- - -
Long Pond, ...	Rochester, ...	33	- - -
Mary's Pond, ¹	Rochester (see Marion), ...	-	- - -
Snipatuit Pond, ...	Rochester, ...	735	Mattapoisett River.
Snows Pond, ...	Rochester, ...	58	- - -
Accord Pond, ²	Rockland (see Hingham), ...	-	- - -
Spring Lake, ...	Rockland, ...	30	Indian Head River.
Herring Brook Pond Lower, ...	Scituate, ...	14	- - -
Herring Brook Pond Upper, ...	Scituate, ...	12	- - -
The Gulf, ...	Scituate, ...	49	- - -
Bartlett Marsh Pond, ...	Wareham, ...	10	Brook.
Beaver Dam Pond, ...	Wareham, ...	10	- - -
Blackmore Pond, ¹	Wareham, ...	27	Branch, ^{Hammond} Brook.
Pond north of same, ...	Wareham, ...	125	Weweantic River.
Pond northwest of South Wareham, ...	Wareham, ...	18	Weweantic River.
Clear Pond, ¹	Wareham, ...	42	- - -
Flax Pond, ...	Wareham, ...	22	- - -
Glen Charlie Pond, ...	Wareham, ...	124	Agawam River.
Jonathans Pond, ²	Wareham, ...	16 ³	- - -
Mosquito Pond, ...	Wareham, ...	14	Brook.
Parker Mills Pond, ...	Wareham, ...	127	- - -
Pickerei Pond, ¹	Wareham, ...	12	- - -
Spectacle Pond, ¹	Wareham, ...	67	Agawam River.
Sturtevant's Pond, ²	Wareham, ...	13	- - -

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PLYMOUTH COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Swifts Pond, ...	Wareham, ...	45	Brook to Onset Bay.
Tihonet Pond, ...	Wareham, ...	62	Wankineo River.
Tremont Pond, ...	Wareham, ...	50	- - -
White Island Pond, . . .	Wareham (see Plymouth),	-	- - -
Pond near Cochesett, . .	West Bridgewater, . .	31	- - -
Whitman Reservoir, . .	Whitman (see Abington),	-	- - -

SUFFOLK COUNTY.

(Total acreage of ponds listed, about 240.)

Chandlers Pond, ...	Boston, ...	12	- - -
Chestnut Hill Reservoir, .	Boston, ...	123	- - -
Cotton Mill Pond at Readville.	Boston, ...	23	Mother Brook.
Jamaica Pond, ...	Boston, ...	68	- - -
Strong Pond, ...	Boston 4 acres and Newton 7 (Middlesex County).	4	- - -
Turtle Pond, ...	Boston, ...	10	- - -

WORCESTER COUNTY.

(Total acreage of ponds listed, about 28,862.)

Lower Naukeag Pond, ¹ . .	Ashburnham, ...	280 ²	Branch, Millers River.
Marble Pond, ...	Ashburnham, ...	12 ²	- - -
Mud Pond, ...	Ashburnham, ...	12	Branch, Millers River.
Nashua Reservoir, . . .	Ashburnham 151 acres and Gardner 61.	212	Branch, Millers River.
Phillips Brook Pond, . .	Ashburnham, ...	12	- - -
Pond in northwest part, .	Ashburnham, ...	17	Bear Meadow Brook.
Rices Reservoir, ...	Ashburnham, ...	115 ²	- - -
South Village Pond, . . .	Ashburnham, ...	25	Whitmans River.
Stodge Meadow Pond, . .	Ashburnham, ...	110 ²	Phillips Brook.
Upper Naukeag Pond, ² . .	Ashburnham, ...	243 ²	Brook to Lower Naukeag Pond.
Ward Pond, ...	Ashburnham, ...	51	Brook to Watatic Pond.
Watatic Pond, ...	Ashburnham 16 acres and Ashby 16 (Middlesex County).	16	Souhegan River.
Eagleville Reservoir, ¹ . .	Athol 44 acres, New Salem 96 and Orange 76 (Franklin County).	44	- - -
Ellis Pond southeast of center.	Athol, ...	52	- - -
Pond near Petersham line, .	Athol, ...	24	- - -

¹ Surveyed.² Area taken from large scale plans or from reliable local source.³ Used as a source of water supply.

WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Reservoir at town line,	Athol 8 acres and Peterham 108.	116	Brook.
Reservoir at town line,	Athol 9 acres and Phillipston 68.	76	Brook.
Pond north of same,	Athol, ...	20	- - -
White Pond, ...	Athol, ...	34	Branch, Millers River.
Pond south of same,	Athol, ...	66	Branch, Millers River.
Dunns Pond, ...	Auburn, ...	25	Brook.
Eddy Pond, ...	Auburn, ...	35	Dark Brook.
Hopeville Pond, ...	Auburn 105 acres and Worcester 50.	155	- - -
Pondville Pond, ...	Auburn, ...	50	- - -
Stoneville Pond, ...	Auburn, ...	67	Kettle Brook.
Pond north of same,	Auburn, ...	42	Kettle Brook.
Mill Pond, east part, ...	Barre, ...	16	Burnshirt River.
Pond southeast of centre, ...	Barre, ...	13	Prince River.
Reservoir, ...	Barre, ...	170	Prince River.
Hudson Reservoir or Gate Pond, ¹	Berlin, ...	84 ²	Branch, Assabet River.
Wheeler's Pond, ...	Berlin, ...	24	Branch, North Brook.
Harris Pond, ...	Blackstone 54 acres and Woonsocket 16 (Rhode Island).	54	Mill River.
Little Pond, ...	Bolton, ...	11	- - -
West Pond, ...	Bolton, ...	15	Branch, Assabet River.
Newton Pond, ...	Boylston 12 acres and Shrewsbury 23.	35	Quinsigamond River.
Pout Pond, ...	Boylston, ...	12	- - -
Rocky Pond, ...	Boylston, ...	46	Cold Harbor Brook.
Sewell Pond, ...	Boylston, ...	12	Brook.
Spruce Pond, ...	Boylston, ...	10	- - -
Wachusett Reservoir, ^{1, 2, 4}	Boylston 2,340 acres, Clinton 890, Sterling 240 and West Boylston 665.	4,135 ²	- - -
Dunn Brook Pond, ...	Brookfield 4 acres and North Brookfield 8.	12	- - -
Lake Lashaway or Furnace Pond, ²	Brookfield 99 acres and North Brookfield 194.	293 ²	East Brookfield River.
Mill Pond southeast of same,	Brookfield, ...	14	Seven Mile River.
Quaboag Pond or Podunk, ²	Brookfield, ...	512	Quabaug River.
Pond west of same, ...	Brookfield, ...	10	- - -
Rices Pond, ...	Brookfield, ...	22	Mason Brook.
Rices Reservoir, ...	Brookfield, ...	40	Mason Brook.

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WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
South Pond or Quasumquassit Pond.	Brookfield 168 acres and Sturbridge 117.	285	Brook to Quabaug Pond.
Bloods Pond,	Charlton 46 acres and Dudley 4.	50	Branch, Quinebaug River.
Buffinville Pond,	Charlton 12 acres and Oxford 13.	25	- - -
Cranberry Meadow Pond,	Charlton 6 acres and Spencer 58.	64	Cranberry Brook.
Gore Pond,	Charlton 127 acres and Dudley 95.	222	Brook to Charlton River.
Hicks Pond,	Charlton,	58	Cady Brook.
Phillips Reservoir,	Charlton,	52	- - -
Pierpont Meadow Pond,	Charlton 7 acres and Dudley 93.	100	Little River.
Pond west of Charlton City,	Charlton,	18	Cady Brook.
Pond north of same,	Charlton,	21	Cady Brook.
Pond east of North Village,	Charlton,	21	- - -
Pond northeast of depot,	Charlton,	12	- - -
Slaters Reservoir,	Charlton,	125	Little River.
South Charlton Reservoir,	Charlton,	240	Brook.
Pond east of same,	Charlton,	12	Brook.
Clam Shell Pond,	Clinton,	17	Branch of Assabet River.
Clinton Mill Pond,	Clinton,	193	- - -
Wachusett Reservoir,	Clinton (see Boylston),	-	- - -
Neesponset Pond,	Dana,	100	Middle Branch, Swift River.
Pottapog Pond,	Dana,	254	East Branch, Swift River.
Sunk Pond,	Dana,	19	Branch, Middle Branch, Swift River.
Bad Luck Pond,	Douglas,	67	Brook to Reservoir.
Manchaug Lake, ¹	Douglas 187 acres and Sutton 173.	360 ²	- - -
Pond near railroad,	Douglas,	40	- - -
Pond north of railroad,	Douglas,	31	- - -
Wallum Pond,	Douglas 133 acres and Burrillville 153 (Rhode Island).	133	Brook.
Willis Pond Reservoir,	Douglas,	250	Brook to Reservoir.
Blood Pond,	Dudley (see Charlton),	-	- - -
Gore Pond,	Dudley (see Charlton),	-	- - -
Hayden Pond,	Dudley,	93	Brook to pond south.
Pond south of same,	Dudley,	22	Brook to pond south.
Larned Pond,	Dudley,	100 ³	Brook to Merino Pond.
Merino Pond,	Dudley,	83 ³	Branch, French River.
Mill Pond,	Dudley,	20 ³	- - -
Peter Pond,	Dudley,	44 ³	Brook to Merino Pond.

¹ Surveyed.² Area taken from large scale plans or from reliable local sources.

WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pierpont Meadow Pond, .	Dudley (see Charlton), .	-	- - -
Fallulah Reservoir, ¹ . .	Fitchburg, . . .	15 ²	- - -
Leominster Reservoir, . .	Fitchburg 17 acres and Leominster 191.	208	- - -
Overbrook Reservoir, ¹ . .	Fitchburg, . . .	13 ²	- - -
Scott Reservoir, ^{1,3} . . .	Fitchburg, . . .	35 ²	- - -
Snows Mill Pond, ⁴ . . .	Fitchburg 33 acres and Westminster 5.	38 ²	- - -
Crystal Lake, ^{1,5} . . .	Gardner, . . .	158 ²	Pond Brook.
Pond north of same, . . .	Gardner, . . .	10	Kneeland Brook.
Kendall Pond, . . .	Gardner, . . .	15	Branch, Otter River.
Mill Pond, . . .	Gardner, . . .	12	Brook.
Pond west of same, . . .	Gardner, . . .	24	Brook.
Nashua Reservoir, . . .	Gardner (see Ashburnham).	-	- - -
Otter River Mill Pond, ⁴ .	Gardner 18 acres and Templeton 18.	36 ²	- - -
Pond at West Gardner, . .	Gardner, . . .	40	Branch, Otter River.
South Gardner Reservoir, .	Gardner 86 acres and Westminster 107.	193	Brook.
Widow Wood Pond, . . .	Gardner, . . .	22	- - -
Flints Pond, ⁴ . . .	Grafton 90.5 acres, Shrewsbury 196.5 and Worcester 29.	316	Brook to Hovey Pond.
Goddards Pond, . . .	Grafton, . . .	76	Quinsigamond River.
Hoveys Pond, . . .	Grafton, . . .	41	- - -
Jourdans Pond, . . .	Grafton (see Upton), .	-	- - -
Pond in northeast part, . .	Grafton, . . .	12	Miscoe Brook.
Pond near Farnamsville, .	Grafton, . . .	101	- - -
Silver Lake, . . .	Grafton, . . .	16	Miscoe Brook.
Moose Brook, . . .	Hardwick, . . .	10	- - -
Muddy Pond, . . .	Hardwick, . . .	99	Muddy Brook.
Pond north of same, . . .	Hardwick, . . .	14	Muddy Brook.
Pond east of Dead Pond, . .	Hardwick, . . .	18	- - -
Bare Hill Lake, . . .	Harvard, . . .	330	Nonecanicus Brook.
Hell Pond, . . .	Harvard, . . .	14	Branch to Nashua River.
Asnebumsket Pond, . . .	Holden, . . .	27	- - -
Chaffins Pond, . . .	Holden, . . .	87	Branch, Quinsigamond River.
Eagleville Pond, . . .	Holden, . . .	67	Quinapoxet River.

¹ Used as a source of water supply.² Area taken from large scale plans or from reliable local source.³ Wholly artificial.⁴ Surveyed.⁵ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.

WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Kendall Reservoir, ¹ ²	Holden, ...	175	- - -
Lower Holden Reservoir or Tatnuck Reservoir No. 2, ¹ ³	Holden, ...	52.6 ⁴	- - -
Upper Holden Reservoir or Tatnuck Reservoir No. 1, ¹ ³	Holden, ...	130 ³	- - -
Pine Hill Reservoir (incomplete).	Holden 45 acres, Paxton 95 and Rutland 12.	152 ⁴	- - -
Pond in northeast corner, .	Holden, ...	10	- - -
Pond northeast of Unionville, .	Holden, ...	10	- - -
Pond south of Pine Hill, .	Holden 8 acres and Paxton 17.	25	- - -
Quinapoxet Pond, ...	Holden 10 acres and Princeton 70.	80	Quinapoxet River.
Quinapoxet Village Pond, .	Holden, ...	17	Quinapoxet River.
Rutland Pond, ...	Holden, ...	20	Trout Brook.
Unionville Pond, ...	Holden, ...	15	Branch, Quinapoxet River.
Factory Pond, ...	Hopedale 14 acres and Bellingham 14 (Norfolk County).	14	Charles River.
Hopedale Pond, ...	Hopedale, ...	47	- - -
Aaseconick Pond, ...	Hubbardston, ...	136	Brook.
Brigham Pond, ...	Hubbardston, ...	50	- - -
Lovewell Pond, ...	Hubbardston, ...	109	Ware River.
Mine Hill Pond, ...	Hubbardston, ...	13	- - -
Moosehorn Pond, ...	Hubbardston, ...	106	Brook to Ware River.
Pond north of same, . . .	Hubbardston, ...	23	- - -
Natty Pond, ...	Hubbardston, ...	41	Natty Pond Brook.
Pond south of same, . . .	Hubbardston, ...	17	Natty Pond Brook.
Pond at town line, ...	Hubbardston 6 acres and Princeton 6.	12	- - -
Prentiss Saw Mill Pond, .	Hubbardston, ...	10	- - -
Ropes Reservoir, ...	Hubbardston, ...	42	- - -
Pond north of same, ¹ . .	Hubbardston, ...	80	- - -
Reservoir in west corner, .	Hubbardston, ...	109	Burnshirt River.
Pond southeast of same, .	Hubbardston, ...	10	- - -
Sawyers Pond, ...	Hubbardston, ...	39	Hubbardston Brook.
Waite Pond, ...	Hubbardston, ...	90	Branch, Ware River.
Fort Pond, ...	Lancaster, ...	33	- - -
Little Spectacle Pond, . .	Lancaster, ...	10	Brook to Spectacle Pond.
Spectacle Pond, ...	Lancaster, ...	46	Canoe Brook.
Turners Pond, ...	Lancaster, ...	18	Bow Brook.

¹ Wholly artificial.² Used as a source of water supply.³ Area taken from large scale plans or from reliable local source.⁴ Total to be 345.

WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Whites Pond, ...	Lancaster 28 acres and Leominster 2.	30	Branch, North Branch, Nashua River.
Burncoat Pond, ...	Leicester 92 acres and Spencer 60.	152	Brook to Cedar Meadow Pond.
Cedar Meadow Pond, ...	Leicester, ...	158	Burncoat Brook.
Cherry Valley Pond, ...	Leicester, ...	18	Kettle Brook.
Cherry Valley Lower Pond, ...	Leicester, ...	10	Kettle Brook.
Greenville Reservoir, ...	Leicester, ...	44	Brook to Roehdale Pond.
Grosvener Reservoir, ...	Leicester, ...	26	Rawson Brook.
Henshaw Pond, ...	Leicester, ...	35	Branch, French River.
Kettle Brook Reservoir No. 1 or Manville Reservoir. ^{1, 2}	Leicester, ...	4.54 ³	Kettle Brook.
Kettle Brook Reservoir No. 2.	Leicester, ...	31 ³	- - -
Kettle Brook Reservoir No. 3 or Gagens Pond.	Leicester 12.4 acres and Paxton 25.	37.4 ³	- - -
Leicester Reservoir, ^{1, 2}	Leicester, ...	143 ³	- - -
Lynde Brook Reservoir, ^{1, 2}	Leicester, ...	132 ³	- - -
Pond southwest of center, ...	Leicester, ...	10	Town Meadow Brook.
Roehdale Pond, ...	Leicester, ...	42	French River.
Sargents Pond, ...	Leicester, ...	84	- - -
Shaw Pond, ²	Leicester, ...	80 ³	Shaw Brook.
Stiles Reservoir, ...	Leicester 107 acres and Spencer 204.	401	French River.
Waites Pond, ...	Leicester, ...	30	Kettle Brook.
Colburns Reservoir, ...	Leominster, ...	10	- - -
Distributing Reservoir, ^{1, 2}	Leominster, ...	4.6 ³	- - -
Fall Brook Reservoir, ^{1, 2}	Leominster, ...	82 ³	- - -
Haynes Reservoir, ^{1, 2}	Leominster, ...	58 ³	- - -
Leominster Reservoir, ...	Leominster (see Fitchburg).	-	- - -
Mill Pond at center, ...	Leominster, ...	17	Monocanoc Brook.
Morse Reservoir, ^{1, 2}	Leominster, ...	11 ³	- - -
Pierce Pond, ⁴	Leominster, ...	29 ³	- - -
Pond east of center, ...	Leominster, ...	10	- - -
Pond in southwest corner, ...	Leominster, ...	30	Branch, Justice Brook.
Rocky Pond, ...	Leominster, ...	15	Brook to Reservoir.
Whalom Pond, ^{4, 5}	Leominster 2 acres and Lunenburg 105.	107 ³	Massapoag Pond and Catacoonamug Brook.
Whites Pond, ...	Leominster (see Lancaster),	-	- - -
Dead Pond, ...	Lunenburg, ...	10	- - -

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WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pond south of same, . . .	Lunenburg, ...	13	- - -
Massapoag Pond, ¹ . . .	Lunenburg, ...	38	Branch, Catacoonamug Brook.
Shirley Reservoir, . . .	Lunenburg, ...	386	Catacoonamug Brook.
Whalom Pond, ...	Lunenburg (see Leominster).	-	- - -
Little Pond, ...	Mendon, ...	10	- - -
Nipmuck Pond, ...	Mendon, ...	66	Brook to Little Pond.
Pond east of Muddy Brook,	Mendon, ...	11	- - -
Pond north Wigwam Hill,	Mendon, ...	14	- - -
Cedar Swamp Pond, . . .	Milford, ...	95	Charles River.
Fiske Mill Pond, ...	Milford 10 acres and Upton 10.	20	- - -
North Pond, ²	Milford 8 acres and Hopkinton 226 (Middlesex County).	8 ³	Mill River.
Dorothy Pond, ¹	Millbury, ...	75	Dorothy Brook.
Lower Mill Pond, ...	Millbury, ...	12	Singletery Brook.
Pond northwest of village,	Millbury, ...	42	Blackstone River.
Ramshorn Pond, ...	Millbury 64 acres and Sutton 36.	99	Ramshorn Brook.
Singletery Pond, ...	Millbury 80 acres and Sutton 276.	356	Singletery Brook.
Pond in east village, . . .	Millville, ...	14	- - -
Brooks Pond, ...	New Braintree 8 acres, North Brookfield 163 and Oakham 9.	200	Five Mile River.
Double Pond near center, .	New Braintree, ...	80	Sucker Brook.
Horse Pond, ...	New Braintree, ...	32	Branch, Five Mile River.
Brooks Pond, ...	North Brookfield (see New Braintree).	-	- - -
Doane Pond Reservoir, . .	North Brookfield, . . .	31 ⁴	- - -
Dunn Brook Pond, ...	North Brookfield (see Brookfield).	-	- - -
Lake Leashaway or Furnace Pond.	North Brookfield (see Brookfield).	-	- - -
Mill Pond on Meadow Brook,	North Brookfield, . . .	12	- - -
North Pond Reservoir, . .	North Brookfield, . . .	70 ⁵	- - -
Pond in northwest part, .	North Brookfield, . . .	12	Meadow Brook.
Pond south of Horse Pond, .	North Brookfield, . . .	10	- - -
Bartlett Pond, ...	Northborough, ...	45	Stirrup Brook.
Little Chauncey Pond, . .	Northborough, ...	16	Brook to Bartlett Pond.
Lower Reservoir, ⁴ ⁵ . . .	Northborough, ...	9 ³	- - -
Pond at Linwood, ...	Northborough, ...	15	Mumford River.

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² Surveyed.

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⁴ Wholly artificial.

⁵ Used as a source of water supply.

WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Pummet Brook Pond, . . .	Northborough, . . .	14	- - -
Smith Pond, . . .	Northborough, . . .	18	Branch, Assabet River.
Solomon Pond, . . .	Northborough, . . .	15	- - -
Mumford Pond, . . .	Northbridge, . . .	32	- - -
Pond at Rockdale, . . .	Northbridge, . . .	45	Blackstone River.
Pond southeast of same, . . .	Northbridge, . . .	15	Mumford River.
Swan or Burt Pond, . . .	Northbridge 6 acres and Sutton 20.	26	Mumford River.
Whitins Pond, . . .	Northbridge 272 acres, Sutton 39 and Uxbridge 39.	350	Mumford River.
Brooks Pond, . . .	Oakham (see New Brain-tree).	-	- - -
Browning Pond, . . .	Oakham 71 acres and Spencer 18.	89	Seven Mile River.
Muddy Pond, . . .	Oakham 32 acres and Rutland 26.	57	Muddy Pond Brook.
Pond southeast of center, . . .	Oakham, . . .	15	Five Mile River.
Buffinville Pond, . . .	Oxford (see Charlton), . . .	-	- - -
Bugg Pond, . . .	Oxford, . . .	10	French River.
Carbuncle Pond, . . .	Oxford, . . .	16	- - -
Howarths Lower Pond, . . .	Oxford, . . .	14	French River.
Howarths Upper Pond, . . .	Oxford, . . .	52	French River.
Hudsons Pond, . . .	Oxford, . . .	11	- - -
Lowes Pond, . . .	Oxford, . . .	57	Branch, French River.
Pond northwest of village, . . .	Oxford, . . .	28	- - -
Pond on town line, . . .	Oxford 16 acres and Sutton 16.	32	French River.
Popes Pond, . . .	Oxford, . . .	42	French River.
Robinson Pond, . . .	Oxford, . . .	100	French River.
Slaters Reservoir or Sacarappa Pond.	Oxford, . . .	125	- - -
Thayer Pond, . . .	Oxford, . . .	50	French River.
Eames Pond, . . .	Paxton, . . .	93	Turkey Hill Brook.
Kettle Brook Reservoir No. 3 or Gagens Pond.	Paxton (see Leicester), . . .	-	- - -
Kettle Brook Reservoir No. 4 or Bottomly Pond. ¹	Paxton, . . .	119 ²	Kettle Brook.
Nanbumskit Pond, . . .	Paxton, . . .	35	Asnebumskit Brook.
Pine Hill Reservoir, . . .	Paxton (see Holden), . . .	-	- - -
Pond south of same, . . .	Paxton (see Holden), . . .	-	- - -
Turkey Hill Brook Pond, . . .	Paxton, . . .	10	- - -
Turkey Hill Pond, . . .	Paxton 32 acres and Rutland 33.	65	Turkey Hill Brook.
Upper Reservoir, ¹ . . .	Paxton, . . .	25	Brook to Bottomly Pond.
Double Pond east of center, . . .	Petersham, . . .	26	- - -

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WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Fever Brook Pond, . . .	Petersham, ...	35	- - -
Pond in north part, . . .	Petersham, ...	10	- - -
Reservoir at town line, . .	Petersham (see Athol), . .	-	- - -
Reservoir south of same, . .	Petersham, ...	112	East Branch, Fever Brook.
Browns Pond, ...	Phillipston 21 acres and Templeton 21.	42	Burnshirt River.
Buckman Park Reservoir, ^{1, 2}	Phillipston, ...	15 ³	- - -
Phillipston Reservoir, ^{1, 2} .	Phillipston, ...	17 ³	- - -
Phillipston Pond, ...	Phillipston, ...	160	Brook.
Reservoir at town line, . .	Phillipston (see Athol), . .	-	- - -
Reservoir east of same, . .	Phillipston, ...	52	- - -
School Pond, ...	Phillipston, ...	15	Branch, Beaver Brook.
Babcock Brook Pond, . . .	Princeton, ...	10	- - -
Keyes Brook Lower, ...	Princeton, ...	20	- - -
Keyes Brook Upper, ...	Princeton, ...	10	- - -
Pond in east part, ...	Princeton, ...	17	- - -
Pond northwest of same, . .	Princeton, ...	10	- - -
Pond at town line, ...	Princeton (see Hubbardston).	-	- - -
Quinapoxet Pond, ...	Princeton (see Holden), . .	-	- - -
Wachusett Lake, ²	Princeton 32 acres and Westminster 104.	136 ³	Brook to Grassy Pond.
Long Pond, ...	Royalston, ...	47	Tully River.
Pond east of same, ...	Royalston, ...	20	- - -
Pond east of center, ...	Royalston, ...	29	Lawrence Brook.
Pond south of road, ...	Royalston, ...	23	Lawrence Brook.
Tully Pond, ...	Royalston, ...	32	- - -
Deemond Pond, ...	Rutland, ...	57	Brook to Long Pond.
Long Pond, ...	Rutland, ...	208	Long Pond Brook.
Moulton Pond, ...	Rutland, ...	48	- - -
Muddy Pond, ...	Rutland (see Oakham), . .	-	- - -
Muschopauge Pond, ²	Rutland, ...	58	Quinapoxet River.
Pine Hill Reservoir, ...	Rutland (see Holden), . .	-	- - -
Pond in north part, ...	Rutland, ...	10	Ware River.
Turkey Hill Pond, ...	Rutland (see Paxton), . .	-	- - -
Flints Pond, ⁴	Shrewsbury (see Grafton), .	-	- - -

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WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Jordan Pond, ¹	Shrewsbury,	27	Branch, Quinsigamond River.
Lake Quinsigamond, ¹	Shrewsbury 399 acres and Worcester 147.	546 ²	Quinsigamond River.
Newton Pond,	Shrewsbury (see Boylston),	-	- - -
Brigham Pond,	Southborough,	10	Stony Brook.
Huntington Mill Pond, ³	Southborough 8 acres and Ashland 8 (Middlesex County).	8 ³	- - -
Pond north of Fayville,	Southborough,	12	Stony Brook.
Pond near Southville, ³	Southborough 6 acres and Hopkinton 5 (Middlesex County).	6 ³	Sudbury River.
Sudbury Reservoir,	Southborough 1,000 acres and Marlborough 292 (Middlesex County).	1,000	- - -
Globe Village Pond,	Southbridge,	24	Quinebaug River.
Hatchet Reservoir No. 1, ⁴ ⁵	Southbridge,	5 ³	- - -
Hatchet Reservoir No. 2, ⁴ ⁵	Southbridge,	8.5 ³	- - -
Hatchet Reservoir No. 3, ⁴ ⁵	Southbridge,	22 ³	- - -
Hatchet Reservoir No. 4, ⁴ ⁵	Southbridge,	67 ³	- - -
Mill Pond on Quinebaug River.	Southbridge,	16	- - -
Pond in southeast corner,	Southbridge,	10	Brook.
Browning Pond,	Spencer (see Oakham),	-	- - -
Burncoat Pond,	Spencer (see Leicester),	-	- - -
Cranberry Meadow Pond,	Spencer (see Charlton),	-	- - -
Pond at center,	Spencer,	11	- - -
Pond southwest of center,	Spencer,	42	Seven Mile River.
Pond in northeast corner,	Spencer,	132	Turkey Hill Brook.
Pond south of Hillsville,	Spencer,	15	Seven Mile River.
Pond in Wire Village,	Spencer,	12	Turkey Hill Brook.
Pond east of Wire Village,	Spencer,	91 ³	- - -
Stiles Reservoir,	Spencer (see Leicester),	-	- - -
Whittemore or Moose Pond,	Spencer,	54	Seven Mile River.
Bailey Brook Pond,	Sterling,	10	- - -
East Wauahacum Pond,	Sterling,	105	Brook to West Wauahacum Pond.
Fitch Pond Reservoir, ⁶	Sterling,	13 ³	South Meadow Brook.
Heywood Reservoir, ⁶	Sterling,	16 ³	- - -
Lower Lynde Reservoir, ⁴ ⁵	Sterling,	4 ³	- - -

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³ Surveyed.

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WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Upper Lynde Reservoir, ^{1, 2}	Sterling, ...	7 ³	- - -
Pond east of Kendall Hill, .	Sterling, ...	10	- - -
Pond east of Rocky Hill, .	Sterling, ...	12	- - -
Pond northwest Justice Brook.	Sterling, ...	32	Justice Brook.
Pratts Junction Pond, . . .	Sterling, ...	15	- - -
Wachusett Reservoir, . . .	Sterling (see Boylston), .	-	- - -
West Waushacum Pond, . . .	Sterling, ...	123	Branch, Still Water River.
Alum Pond, ...	Sturbridge, ...	172	Brook to Long Pond.
Cedar Pond, ...	Sturbridge, ...	190	Branch, Quinebaug River.
Pond north of same, ...	Sturbridge, ...	33	Brook to Cedar Pond.
Lead Mine Pond, ...	Sturbridge, ...	68	Lead Mine Brook.
Long Pond, ...	Sturbridge, ...	219	Branch, Quinebaug River.
South Pond or Quacumquasit Pond.	Sturbridge (see Brookfield),	-	- - -
Walker Pond, ...	Sturbridge, ...	100	Hobbs Brook.
Breakneck Reservoir, ^{1, 2}	Sutton, ...	10	- - -
Cook Allen Reservoir, ^{1, 2}	Sutton, ...		
Clarks Reservoir, ²	Sutton, ...	40	Cold Spring Brook.
Manchaug Lake, ⁴	Sutton (see Douglas), .	-	Brook to next pond.
Pond north of same, ...	Sutton, ...	22	Mumford River.
Pleasantdale Pond, ...	Sutton, ...	26	Cold Spring Brook.
Pond north of Manchaug Village.	Sutton, ...	58	Brook.
Pond southwest of same, . .	Sutton, ...	75	Brook.
Pond at Wilkinsonville, . .	Sutton, ...	14	Blackstone River.
Pond north of same, ...	Sutton, ...	17	Blackstone River.
Pond on town line, ...	Sutton (see Oxford), .	-	- - -
Ramshorn Pond, ...	Sutton (see Millbury), .	-	- - -
Reservoir No. 5, ^{1, 2}	Sutton, ...	40	- - -
Sibley Reservoir, ...	Sutton, ...	55	Cold Spring Brook.
Singletary Pond, ...	Sutton (see Millbury), .	-	- - -
Swan or Burt Pond, ...	Sutton (see Northbridge),	-	- - -
Whitins Pond, ...	Sutton (see Northbridge),	-	- - -
Browns Pond, ...	Templeton (see Phillips-ton),	-	- - -
Burnshirt Pond, ...	Templeton, ...	90	- - -
Lower Pond east of Brooks Village.	Templeton, ...	35	Trout Brook.
Upper Pond east of Brooks Village.	Templeton, ...	35	Brook to Lower Pond.

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WORCESTER COUNTY — *Continued.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Otter River Mill Pond,	Templeton (see Gardner),	-	- - -
Pond at Baldwinville,	Templeton, . . .	20	Otter River.
Pond southeast of Baldwinville.	Templeton, . . .	92	- - -
Pond at East Templeton,	Templeton, . . .	46	Branch, Otter River.
Pond north of Otter River Village.	Templeton, . . .	12	- - -
Pond at Partridgeville,	Templeton, . . .	30	Branch, Otter River.
Fiske Mill Pond, . . .	Upton (see Milford),	-	- - -
Jourdans Pond, ¹ . . .	Upton, . . .	48 ²	West River.
Pratts Pond, . . .	Upton, . . .	22	Center Brook.
Zachary Pond, . . .	Upton, . . .	10	West River.
Chocalog Pond, . . .	Uxbridge, . . .	20	Nipmuck River.
Ironstone Reservoir, . .	Uxbridge 88 acres and North Southfield 48 (Connecticut).	38	Branch, Blackstone River.
Pond at North Village,	Uxbridge, . . .	25	Mumford River.
Pond northeast of same,	Uxbridge, . . .	75	Blackstone River.
Pond south of North Village,	Uxbridge, . . .	18	- - -
Pout Pond, . . .	Uxbridge, . . .	10	West River.
Whitins Pond, . . .	Uxbridge (see North-bridge).	-	- - -
Comins Pond, . . .	Warren, . . .	15	- - -
Mill Pond, . . .	Warren, . . .	27	- - -
Mill Pond, . . .	Warren, . . .	13	- - -
Mill Pond, . . .	Warren, . . .	57	- - -
Lake Chaubunagungamaug, ^{1, 2, 4}	Webster, . . .	1,188 ³	Mill Brook.
Pond in north part, . .	West Boylston, . . .	28	Shaker Brook.
Wachusett Reservoir, . .	West Boylston (see Boylston).	-	- - -
Wickaboag Pond, . . .	West Brookfield, . . .	320	Branch, Quabaug River.
Cedar Swamp Pond, . . .	Westborough, . . .	22	Sudbury River.
Hocomonook Pond, . . .	Westborough, . . .	15	Branch, Assabet River.
Lake Chauncey, . . .	Westborough, . . .	197	Brook to Little Chauncey Pond.
Pond east of Faye Mountain,	Westborough, . . .	53	- - -
Adams Reservoir or Coolidge,	Westminster, . . .	73	Whitmans River.
Grassy Pond or Wyman Reservoir, ⁴	Westminster, . . .	255 ³	Branch, Flagg Brook.
Meeting House Pond, ⁴ . .	Westminster, . . .	152 ³	Brook to Grassy Pond or Wyman Reservoir.
Merriams or Round Meadow Reservoir, ⁴	Westminster, . . .	62 ³	Whitmans River.

¹ Surveyed.² Area taken from large scale plans or from reliable local sources.³ Licenses have been granted by the Commission on Waterways and Public Lands or its predecessors.⁴ Used as a source of water supply.

WORCESTER COUNTY — *Concluded.*

NAME.	City or Town.	Approximate Area in Acres.	Outlet.
Minots Pond, ...	Westminster, ...	18	Brook to South Gardner Reservoir.
Muddy Pond, ...	Westminster, ...	12	Branch, Whitmans River.
Reservoir west of Westminster.	Westminster, ...	50	- - -
Pond south of same, . . .	Westminster, ...	23	- - -
Snows Mill Pond, ...	Westminster (see Fitchburg).	-	- - -
South Ashburnham Reservoir.	Westminster, ...	116 ¹	Whitmans River.
South Gardner Reservoir, .	Westminster (see Gardner),	-	- - -
Wachusett Lake, ...	Westminster (see Princeton).	-	- - -
Bullardville Pond, ...	Winchendon, ...	17	Branch, Millers River.
Carter & Stoddards Pond, .	Winchendon, ...	27	Branch, Otter River.
Denison Lake, ...	Winchendon, ...	85	Branch, Millers River.
Lake Monomonic, ...	Winchendon 292 acres and Rindge 352 (New Hampshire).	292	Millers River.
Reservoir, ...	Winchendon, ...	116	Branch, Millers River.
Springville Pond, ...	Winchendon, ...	22	- - -
Pond southwest of same, .	Winchendon, ...	12	- - -
Whitneys Upper Mill Pond, .	Winchendon, ...	110 ¹	Millers River.
Pond near same, ...	Winchendon, ...	12	- - -
Coes Reservoir, ...	Worcester, ...	118	Tatnuck Brook.
Curtis Pond, ...	Worcester, ...	52	Blackstone River.
Flints Pond, ...	Worcester (see Grafton), .	-	- - -
Green Hill Pond, ...	Worcester, ...	27	- - -
Hopeville Pond, ...	Worcester (see Auburn), .	-	- - -
Jamesville Pond, ...	Worcester, ...	21	- - -
Lake Quinsigamond, ...	Worcester (see Shrewsbury).	-	- - -
Patches Pond southeast of Tatnuck Village.	Worcester, ...	55	Tatnuck Brook.
Pond south of South Ware, .	Worcester, ...	33	- - -
Salisbury Pond, ...	Worcester, ...	25 ¹	Mill Brook.
Thayers Reservoir north of Tatnuck Village.	Worcester, ...	20	Tatnuck Brook.

¹ Area taken from large scale plans or from reliable local source.

APPENDIX II.

RECORDS OF STREAM FLOW FOR THE TWO-YEAR PERIOD ENDING SEPT. 30, 1917.

GAGING STATIONS.

The following list comprises the gaging stations maintained in Massachusetts by the United States Geological Survey in co-operation with the Commission on Waterways and Public Lands. Two stations outside of Massachusetts are included in this list by reason of their value in connection with studies of streams within the State. Tributaries of main streams are indicated by indention. The date shows the years or parts of years for which records are available.

- Housatonic River near Great Barrington, Mass., 1913-17.
- Housatonic River at Falls Village, Conn., 1912-17.
- Connecticut River at Sunderland, Mass., 1904-17.
- Millers River near Winchendon, Mass., 1916-17.
- Millers River at Erving, Mass., 1914-17.
- Sip Pond Brook near Winchendon, Mass., 1916-17.
- Priest Brook near Winchendon, Mass., 1916-17.
- Otter River near Gardner, Mass., 1916-17.
- East Branch of Tully River near Athol, Mass., 1916-17.
- Moss Brook at Wendell depot, Mass., 1916-17.
- Deerfield River at Charlemont, Mass., 1913-17.
- Chicopee River: —
 - Ware River at Gibbs Crossing, Mass., 1912-17.
 - Swift River at West Ware, Mass., 1910-17.
 - Quaboag River at West Brimfield, Mass., 1909-17.
 - Westfield River at Knightville, Mass., 1909-17.
 - Westfield River near Westfield, Mass., 1914-17.
 - Middle Branch of Westfield River near Goss Heights, Mass., 1910-17.
 - Farmington River near New Boston, Mass., 1913-17.
- Blackstone River at Albion, R. I., 1914-16.

Housatonic River near Great Barrington, Mass.

Location. — At highway bridge about one-fourth mile north-east of Van Deusenville station of New York, New Haven & Hartford Railroad (Berkshire division), and 2 miles north of Great Barrington.

Drainage Area. — Square miles, 280.

Records available. — May 17, 1913, to Sept. 30, 1917.

Gage. — Inclined staff attached to concrete anchorages on down-stream side of left abutment of highway bridge; vertical high-water section attached to bridge abutment; read by Martin Love.

Discharge Measurements. — Made from up-stream side of highway bridge or by wading.

Channel and Control. — Bed composed of sand and gravel; control practically permanent.

Extremes of Discharge. — Maximum stage recorded during year ending Sept. 30, 1916, 8.0 feet at 5 P.M. March 31 (approximate discharge by extension of rating curve, 5,300 second-feet); minimum stage recorded during year, 0.8 foot at 7 A.M. November 7 (discharge, 22 second-feet).

Maximum stage recorded during year ending Sept. 30, 1917, 6.9 feet from 8.30 A.M. March 28, to 8.30 A.M. March 29 (discharge, 4,200 second-feet); minimum stage recorded during year, 0.7 foot at 8 A.M. September 27 (discharge, 13 second-feet).

Maximum stage recorded, 1913-17, 8.0 feet on March 31, 1916 (approximate discharge, 5,300 second-feet). Zero flow recorded on morning of Aug. 11, 1914.

Ice. — Stage-discharge relation occasionally affected by ice for short periods during the winter.

Regulation. — Storage above dam of a paper mill about a mile above station causes low flow on Sundays and holidays.

Accuracy. — Stage-discharge relation evidently changed during the high water of December, 1916. Rating curve used before December 26 well defined below 1,700 second-feet; curve used after that date fairly well defined by discharge measurements below 1,400 second-feet and by shape of old curve. Stage-discharge relation affected by ice for a few days in February of both years. Gage read to quarter-tenths twice daily. Daily discharge ascertained by applying the rating table to mean daily gage heights. Results fair.

*Discharge Measurements of Housatonic River near Great Barrington, Mass.,
during the Two-year Period ending Sept. 30, 1917.*

DATE.	Made by —	Gage Height (Feet).	Dis- charge (Second- feet).
Dec. 22, ... 1915.	Hardin Thweatt, ...	3.09	996
Jan. 23, ... 1916.	Hardin Thweatt, ...	3.56	1,350
Sept. 13, ...	Hardin Thweatt, ...	1.67	181
Sept. 13, ...	Hardin Thweatt, ...	1.68	179
Nov. 12, ...	Hardin Thweatt, ...	1.28	96
Jan. 7, ... 1917.	A. H. Davison, ...	2.25	468
Jan. 7, ...	A. H. Davison, ...	2.32	503
Aug. 9, ...	M. R. Stackpole, ...	1.84	274
Aug. 9, ...	M. R. Stackpole, ...	1.69	210

Daily Discharge, in Second-feet, of Housatonic River near Great Barrington, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.			1916.										
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.		
1.	355	189	210	1,060	2,060	730	3,500	990	340	390	290	160		
2.	180	225	315	950	2,140	700	3,000	720	310	300	205	65		
3.	132	153	325	990	1,520	640	3,060	740	290	300	220	57		
4.	375	180	285	790	1,600	560	3,140	640	365	315	190	120		
5.	275	210	112	530	1,300	380	2,140	610	415	415	230	110		
6.	105	140	153	690	930	480	1,620	740	550	390	115	90		
7.	225	48	165	990	820	485	1,850	810	440	320	240	205		
8.	345	165	228	990	830	520	1,950	550	390	220	220	140		
9.	245	180	210	670	790	520	1,340	550	340	260	205	102		
10.	310	180	275	700	730	520	1,350	550	300	415	175	110		
11.	335	195	100	730	550	415	1,350	440	300	340	128	150		
12.	315	195	87	490	390	360	1,700	390	410	300	140	100		
13.	275	156	122	390	390	465	2,000	320	390	415	200	122		
14.	372	150	145	340	390	465	2,000	320	390	190	100	390		
15.	275	190	145	340	390	465	2,000	320	390	190	100	390		
16.	75	312	141	340	490	415	2,760	320	240	340	140	390		
17.	159	292	196	490	640	380	2,760	320	305	390	140	390		
18.	325	292	196	440	640	385	1,620	940	465	300	140	390		
19.	375	315	196	340	465	440	1,650	520	465	300	45	390		
20.	375	315	1,320	440	465	440	1,520	365	440	300	124	390		
21.	265	265	1,190	565	490	465	1,360	490	465	365	140	190		
22.	165	196	1,060	550	580	465	1,360	490	190	390	112	190		
23.	75	140	875	1,200	465	440	1,360	490	190	390	175	106		
24.	100	140	875	990	465	440	1,360	490	280	360	132	160		
25.	150	275	850	1,060	580	390	1,700	580	300	260	175	106		
26.	196	210	870	1,130	670	390	1,600	590	300	260	175	106		
27.	165	210	3,140	1,060	1,130	490	1,280	415	440	320	175	92		
28.	265	87	3,050	3,050	1,060	700	1,280	220	365	280	160	160		
29.	225	166	2,330	2,330	790	1,280	1,060	365	340	150	220	240		
30.	135	166	2,080	2,000	-	1,690	990	305	205	220	220	240		
31.	125	-	1,280	1,700	-	3,900	-	300	-	280	160	-		

Norm. — Stage-discharge relation affected by ice February 13 to 16; discharge estimated from gage heights, observer's notes and weather records.

Daily Discharge, in Second-feet, of Housatonic River near Great Barrington, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	220	205	1,200	300	300	1,060	1,760	520	520	440	84	150
2.	260	190	990	340	340	670	2,690	415	465	490	140	78
3.	260	190	440	260	290	520	2,790	670	290	340	160	136
4.	300	220	465	300	175	390	2,330	670	290	90	150	122
5.	190	62	390	265	390	760	1,840	640	490	175	60	160
6.	175	112	490	520	290	550	1,600	580	490	190	120	138
7.	160	160	340	415	290	240	1,600	790	670	160	84	160
8.	132	205	465	490	320	365	1,130	760	920	130	80	140
9.	116	300	440	580	132	520	1,130	790	610	220	160	77
10.	140	280	300	610	120	415	850	730	390	220	150	118
11.	190	140	260	580	120	160	850	550	640	160	77	140
12.	150	190	550	365	160	580	730	550	760	175	56	150
13.	120	175	520	440	130	670	670	415	700	220	150	84
14.	150	190	320	730	140	610	640	415	610	220	150	112
15.	116	280	340	1,480	190	550	520	490	670	150	98	65
16.	190	260	345	1,160	240	610	580	440	580	140	140	110
17.	140	240	160	1,020	140	700	550	320	440	260	140	110
18.	130	229	200	850	80	670	550	415	390	260	140	110
19.	160	72	265	700	465	610	550	415	340	340	78	96
20.	175	295	300	415	290	465	760	136	340	415	78	92
21.	205	320	265	140	175	550	920	240	340	260	150	104
22.	160	220	200	415	160	700	990	205	240	320	66	70
23.	140	190	670	205	290	640	920	320	240	260	75	90
24.	160	240	490	290	550	1,440	760	390	220	240	122	73
25.	160	550	390	220	110	1,840	670	440	240	220	120	116
26.	175	365	465	205	300	2,340	550	340	290	160	66	128
27.	175	240	465	160	670	2,600	520	160	300	205	102	29
28.	150	175	490	72	1,280	4,200	520	260	365	238	116	175
29.	67	265	415	320	-	4,100	415	640	415	80	124	190
30.	122	860	240	240	-	3,140	440	700	340	190	116	65
31.	160	-	240	160	-	2,060	-	580	-	160	128	-

NOTE. — Stage-discharge relation affected by ice February 10 to 18; discharge determined from study of gage heights, observer's notes and weather records.

*Monthly Discharge of Housatonic River near Great Barrington, Mass., for
the Two-year Period ending Sept. 30, 1917.*

[Drainage area, 280 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1916-16.					
October, ...	375	75	222	.793	.91
November, ...	315	48	189	.675	.75
December, ...	3,700	67	842	3.010	3.47
January, ...	3,140	340	1,000	3.570	4.12
February, ...	2,160	390	829	2.960	3.19
March, ...	3,900	280	655	2.340	2.70
April, ...	4,200	990	1,970	7.040	7.86
May, ...	990	205	527	1.880	2.17
June, ...	550	136	357	1.280	1.43
July, ...	520	150	313	1.120	1.29
August, ...	280	48	174	.621	.72
September, ...	550	51	189	.675	.75
The year, ...	4,200	43	604	2.160	29.36
1916-17.					
October, ...	300	57	166	.593	.68
November, ...	850	62	244	.871	.97
December, ...	1,200	160	438	1.560	1.80
January, ...	1,480	72	462	1.660	1.90
February, ...	1,280	80	291	1.040	1.08
March, ...	4,200	160	1,120	4.000	4.61
April, ...	2,780	415	1,030	3.680	4.11
May, ...	790	136	478	1.710	1.97
June, ...	920	220	453	1.620	1.31
July, ...	490	80	225	.804	.93
August, ...	160	56	112	.400	.46
September, ...	190	29	114	.407	.45
The year, ...	4,200	29	423	1.530	20.77

Housatonic River at Falls Village, Conn.

Location. — About one-half mile below the power plant of the Connecticut Power Company, at Falls Village, 23 miles north of Gaylordsville.

Drainage Area. — Square miles, 644.

Records available. — July 11, 1912, to Sept. 30, 1917.

Gages. — Stevens continuous water-stage recorder on left bank; staff gage inside the well and vertical staff on river bank 25 feet up-stream; chain gage 300 feet up-stream used for auxiliary readings.

Discharge Measurements. — Made by wading.

Channel and Control. — Channel deep and fairly uniform in cross-section; one channel at all times. Control not clearly defined except at low stages; probably permanent.

Extremes of Discharge. — Maximum stage during year ending Sept. 30, 1916, from water-stage recorder, 11.45 feet at 10 A.M. April 3 (discharge, 6,960 second-feet); minimum stage during year from water-stage recorder, practically zero flow at various times during August and September, owing to storage of water above power plant.

Maximum stage during year ending Sept. 30, 1917, from water-stage recorder, 10.40 feet at 10 A.M. March 29 (discharge, 6,000 second-feet); minimum stage during year from water-stage recorder, 0.28 foot at 6.30 P.M. October 15 (discharge, practically zero).

Maximum stage recorded, 1912-17, 13.3 feet on March 29, 1914 (discharge, 8,830 second-feet); minimum stage recorded, zero flow at various times owing to storage of water above power plant.

Ice. — Stage-discharge relation occasionally affected by ice for short periods during the winter.

Regulation. — The flow at low water is completely regulated by the power plant at Falls Village.

Co-operation. — All discharge measurements and computations prior to March 1, 1916, made by engineers of Stone & Webster Engineering Corporation.

Accuracy. — Stage-discharge relation practically permanent, except for periods when it was affected by ice. Rating curve developed for chain gage well defined between 200 and 3,000 second-feet. Above 3,000 second-feet curve extended by logarithmic plotting, using results of 3 float measurements made be-

tween gage heights 12 and 13 feet. Rating table for gage heights from water-stage recorder derived from chain gage rating curve by applying correction for slope between the two gages. Operation of the water-stage recorder satisfactory except for occasional days, as indicated in the footnotes to the daily discharge tables. Daily discharge ascertained as follows: Oct. 1, 1915, to July 31, 1916, by applying rating table to mean daily gage heights determined by planimeter; Aug. 1, 1916, to Sept. 30, 1917, by use of discharge integrator. Results excellent.

Discharge Measurements of Housatonic River at Falls Village, Conn., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
1916.			
Aug. 18, ...	Hardin Thweatt, ...	2.78	657
Aug. 19, ...	Hardin Thweatt, ...	2.68	639
Nov. 14, ...	Hardin Thweatt, ...	1.97	404
Nov. 14, ...	Hardin Thweatt, ...	1.96	410
1917.			
Jan. 6, ...	A. H. Davison, ...	4.49 ¹	1,380
Jan. 28, ...	H. H. Khachadorian, ...	2.13 ¹	299
Mar. 5, ...	A. H. Davison, ...	5.38 ¹	1,320
Mar. 29, ...	Hardin Thweatt, ...	10.62 ¹	3,020
Mar. 29, ...	Hardin Thweatt, ...	10.60 ¹	6,300
Mar. 31, ...	Hardin Thweatt, ...	9.02	4,830
Aug. 10, ...	M. R. Stackpole, ...	2.58	626

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Housatonic River at Falls Village, Conn., for the Year ending Sept. 30, 1916.

DAY.	1915.			1916.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	436	520	412	2,740	3,740	1,980	5,830	1,800	920	567	700	395
2.	512	388	428	2,340	3,650	1,740	6,620	1,620	720	274	670	340
3.	297	424	432	1,880	3,360	1,560	6,720	1,440	675	423	540	270
4.	578	420	408	2,120	2,910	1,390	6,080	1,560	603	945	690	200
5.	402	404	220	2,060	2,580	1,310	5,150	1,500	1,040	1,020	530	350
6.	460	311	460	2,170	2,320	1,140	4,360	1,300	1,040	770	300	335
7.	533	202	396	2,430	1,960	1,170	3,840	1,120	945	770	630	235
8.	583	384	356	2,200	1,640	1,310	3,610	1,310	845	720	470	235
9.	728	400	356	1,870	1,660	1,250	3,250	1,170	820	340	640	300
10.	294	380	484	1,650	1,580	1,120	3,040	1,220	408	945	550	100
11.	632	360	412	1,550	1,460	1,020	2,830	1,070	870	1,040	550	265
12.	472	283	269	1,490	1,360	1,100	2,660	1,020	745	1,020	450	220
13.	547	300	504	1,430	1,110	1,120	2,970	705	745	1,070	450	240
14.	465	183	945	1,540	1,200	1,040	3,180	540	688	2,300	650	220
15.	472	408	619	1,540	1,120	1,040	4,060	945	688	1,800	650	300
16.	460	432	496	1,400	1,290	1,200	4,360	820	675	1,190	530	300
17.	183	408	480	1,180	1,320	1,200	4,140	1,020	603	1,070	360	1,220
18.	440	440	945	1,420	1,240	1,120	3,840	1,080	830	1,020	420	1,260
19.	404	556	1,830	1,500	1,450	1,070	3,540	1,680	1,070	1,000	370	540
20.	538	855	2,880	1,360	1,370	1,070	3,250	1,440	1,070	920	133	685
21.	534	664	3,050	1,340	1,340	985	3,260	1,220	1,070	985	460	535
22.	476	755	2,770	1,440	1,000	920	2,890	1,120	870	830	335	410
23.	444	516	2,480	1,400	1,060	920	2,760	945	870	284	265	640
24.	360	664	2,220	2,850	1,160	845	2,900	1,120	720	698	410	250
25.	380	255	2,040	2,550	1,180	795	2,900	1,120	274	630	435	410
26.	302	590	3,900	2,480	2,660	698	2,600	945	870	795	440	425
27.	382	480	5,240	3,170	2,910	1,100	2,420	845	820	1,120	130	400
28.	380	238	6,670	4,200	2,580	1,500	2,320	1,070	570	1,170	540	420
29.	464	596	5,220	4,770	2,230	2,300	2,160	1,070	745	770	335	440
30.	534	420	3,560	4,060	2,110	3,110	1,960	415	720	532	405	535
31.	190	-	3,560	4,100	-	4,590	-	970	-	630	395	-

Notes. — January 2 and 3, record from water-stage recorder unreliable; discharge estimated.

Daily Discharge, in Second-feet, of Housatonic River at Falls Village, Conn., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	530	315	2,050	600	660	2,100	4,000	1,300	1,340	660	360	500
2.	580	306	1,900	660	700	1,700	4,050	1,300	960	920	415	310
3.	540	400	1,520	630	640	1,300	4,200	1,420	630	740	330	122
4.	580	380	1,320	420	180	860	4,200	1,320	1,040	350	280	245
5.	500	270	900	670	520	880	3,760	1,260	710	680	70	305
6.	445	405	1,000	940	680	720	3,350	2,050	830	576	335	330
7.	540	500	820	1,100	470	880	3,300	1,880	1,110	460	325	290
8.	250	420	840	1,150	360	820	3,150	1,700	1,490	220	345	290
9.	315	370	850	890	490	1,150	2,700	1,660	1,600	400	320	72
10.	310	435	530	840	600	1,000	2,250	1,560	1,440	400	310	320
11.	350	445	870	760	350	880	2,000	1,440	1,440	385	370	330
12.	345	240	770	1,100	540	1,350	1,820	1,290	1,400	560	67	315
13.	365	430	830	940	490	1,400	1,660	1,200	1,500	510	295	365
14.	380	360	760	1,350	480	1,450	1,640	1,380	1,520	550	305	265
15.	125	480	670	2,500	300	1,400	1,440	1,140	1,400	246	310	250
16.	345	440	650	2,200	420	1,400	1,520	1,020	1,360	585	345	66
17.	270	360	660	2,000	480	1,350	1,300	970	1,200	630	345	255
18.	290	480	630	1,700	215	1,350	1,220	960	1,280	720	275	240
19.	360	255	550	1,300	390	1,540	1,260	810	1,280	810	70	230
20.	440	350	580	1,200	370	1,740	1,340	325	1,020	900	325	215
21.	600	420	560	760	430	1,320	1,460	940	960	900	275	180
22.	285	360	580	940	400	1,280	1,640	790	790	440	275	112
23.	475	445	840	890	400	1,600	1,760	620	665	830	555	60
24.	440	910	1,250	820	560	2,550	1,580	810	210	550	245	192
25.	435	1,180	1,150	780	320	3,550	1,480	870	600	530	235	186
26.	335	650	1,200	720	480	4,100	1,280	830	660	560	40	183
27.	340	730	900	780	2,500	4,210	1,240	385	660	470	215	215
28.	430	670	860	660	2,500	4,750	1,300	1,020	850	425	250	200
29.	265	640	740	620	2,500	5,800	1,300	940	770	200	330	172
30.	260	890	740	620	-	5,700	1,360	1,300	850	540	465	98
31.	290	-	570	580	-	4,750	-	1,480	-	385	570	-

NOTE. — Stage-discharge relation affected by ice December 17 to March 16; discharge determined from study of gage-height graph, discharge measurements and weather records.

*Discharge Measurements of Housatonic River near Great Barrington, Mass.,
during the Two-year Period ending Sept. 30, 1917.*

DATE.	Made by —	Gage Height (Feet).	Dis- charge (Second- feet).
1915.			
Dec. 22, ...	Hardin Thweatt, ...	3.09	996
1916.			
Jan. 23, ...	Hardin Thweatt, ...	3.56	1,350
Sept. 13, ...	Hardin Thweatt, ...	1.67	181
Sept. 13, ...	Hardin Thweatt, ...	1.65	179
Nov. 12, ...	Hardin Thweatt, ...	1.28	96
1917.			
Jan. 7, ...	A. H. Davison, ...	2.25	468
Jan. 7, ...	A. H. Davison, ...	2.32	503
Aug. 9, ...	M. R. Stackpole, ...	1.84	274
Aug. 9, ...	M. R. Stackpole, ...	1.69	210

Daily Discharge, in Second-feet, of Housatonic River near Great Barrington, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.			1916.											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.			
1.	355	180	210	1,060	2,080	730	3,500	990	340	390	280	160			
2.	180	225	315	850	2,160	700	4,200	820	340	300	205	65			
3.	122	153	335	990	1,920	640	3,900	760	280	300	220	87			
4.	376	180	265	790	1,600	550	3,140	790	305	365	190	120			
5.	275	210	112	830	1,200	390	2,420	610	415	415	220	110			
6.	196	150	163	990	1,390	490	1,920	760	550	390	116	96			
7.	228	148	165	990	920	465	1,920	465	550	340	240	90			
8.	345	165	225	920	830	280	1,650	610	440	220	190	205			
9.	265	180	210	670	790	520	1,250	550	390	300	220	140			
10.	210	180	275	700	730	530	1,360	550	340	260	205	102			
11.	296	195	100	730	650	520	1,250	550	300	415	175	110			
12.	335	240	67	700	415	415	1,130	440	300	340	128	150			
13.	315	195	87	490	390	390	1,760	390	440	300	140	100			
14.	275	150	122	390	390	520	1,760	320	390	415	260	122			
15.	275	165	165	340	390	465	2,960	305	300	520	190	650			
16.	75	125	150	340	390	490	2,780	390	280	190	190	390			
17.	160	315	141	520	490	415	2,510	520	240	240	190	520			
18.	225	295	195	490	640	390	2,240	700	365	300	140	390			
19.	255	315	185	340	640	365	1,920	990	465	390	140	365			
20.	275	255	1,820	440	465	440	1,650	520	465	300	48	280			
21.	255	255	1,190	365	490	490	1,520	365	440	300	124	260			
22.	165	195	1,060	550	580	465	1,360	490	465	365	140	190			
23.	75	110	910	1,200	465	440	1,360	610	135	260	160	112			
24.	100	147	875	990	465	465	1,600	490	190	300	220	61			
25.	150	275	3,700	1,060	580	390	1,760	580	300	260	175	108			
26.	195	210	3,700	1,130	670	300	1,600	390	300	260	132	160			
27.	165	210	3,140	1,130	1,390	490	1,250	415	440	320	73	175			
28.	255	87	5,050	3,050	1,060	700	1,280	220	365	260	160	92			
29.	225	165	2,330	3,140	790	1,280	1,060	365	340	160	150	160			
30.	135	165	2,080	2,600	-	1,680	990	340	295	220	220	240			
31.	125	-	1,250	1,760	-	3,000	-	300	-	250	160	-			

NOTE. — Stage-discharge relation affected by ice February 13 to 16; discharge estimated from gage heights, observer's notes and weather records.

Daily Discharge, in Second-feet, of Housatonic River near Great Barrington, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.				1917.									
	Oct.	Nov.	Dec.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	
1.	230	205	1,200		300	300	1,060	1,760	520	520	440	84	150	
2.	260	190	900		340	340	570	2,490	415	445	490	140	78	
3.	260	190	445		260	260	530	2,790	670	280	340	150	132	
4.	300	220	465		300	300	760	2,330	670	360	90	150	122	
5.	190	63	390		365	365	390	1,640	580	490	175	60	160	
6.	175	112	490		520	260	550	1,600	580	490	190	120	138	
7.	160	160	340		415	260	240	1,600	790	670	160	84	160	
8.	132	205	465		490	230	365	1,130	790	920	130	80	140	
9.	116	300	440		580	132	530	1,130	730	610	220	160	77	
10.	140	280	300		610	120	415	950	550	390	220	150	116	
11.	190	140	260		580	120	160	730	550	640	160	77	140	
12.	150	190	560		365	160	580	730	550	700	175	56	150	
13.	120	175	520		440	130	670	670	415	700	220	120	150	
14.	150	190	320		730	140	610	640	415	610	220	150	112	
15.	116	280	340		1,480	190	550	520	490	670	220	150	84	
16.	190	260	365		1,160	340	610	580	440	580	150	98	66	
17.	140	240	160		1,020	140	700	550	320	440	140	140	110	
18.	130	220	260		850	80	670	550	415	390	260	140	110	
19.	160	72	365		700	465	610	550	260	440	340	78	96	
20.	175	205	300		415	260	465	760	136	340	415	78	92	
21.	205	230	365		149	175	550	920	240	340	360	150	104	
22.	160	220	300		415	160	700	990	205	340	320	66	70	
23.	140	190	670		205	260	920	920	320	340	260	75	90	
24.	160	240	490		260	560	640	760	330	240	240	122	71	
25.	180	550	390		1,440	110	1,440	670	440	240	230	130	116	
26.	175	365	465		205	300	2,240	560	340	360	160	66	128	
27.	240	465	465		800	300	2,600	520	160	300	205	102	79	
28.	175	175	490		160	1,280	4,200	520	260	365	138	116	175	
29.	67	365	415		320	-	4,100	415	260	415	80	124	190	
30.	122	860	340		240	-	3,140	440	700	340	190	116	66	
31.	160	-	240		160	-	2,060	-	580	-	160	128	-	

NOTE. — Stage-discharge relation affected by ice February 10 to 18; discharge determined from study of gage heights, observer's notes and weather records.

Daily Discharge, in Second-feet, of Connecticut River at Sunderland, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.				1916.								
	Oct.	Nov.	Dec.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	6,720	4,790	9,520		13,300	47,000	22,500	58,200	27,200	13,200	12,600	9,520	4,580
2.	6,620	6,050	9,240		14,000	45,200	20,300	62,800	24,100	14,000	10,100	8,160	4,700
3.	4,210	6,720	10,700		10,700	35,500	18,700	70,100	82,900	14,700	10,100	5,200	3,170
4.	3,670	6,720	10,700		11,700	34,000	16,700	51,500	90,000	17,000	15,700	4,980	2,450
5.	6,490	7,420	6,490		12,000	31,000	19,600	52,800	90,000	15,700	10,000	5,200	3,850
6.	6,270	7,420	7,420		11,300	24,400	12,300	41,000	27,200	17,000	20,600	2,720	5,200
7.	6,950	6,950	7,660		13,000	28,000	12,300	45,900	18,500	21,700	21,400	2,850	4,210
8.	7,420	3,500	6,490		11,700	25,200	12,500	41,400	18,500	21,700	15,400	4,780	4,030
9.	6,270	5,620	6,490		8,950	17,000	12,500	31,400	23,200	22,900	11,300	4,980	2,870
10.	6,050	4,790	5,620		8,420	15,400	11,000	32,800	21,400	21,400	11,000	9,240	2,090
11.	7,660	4,590	5,960		16,100	17,400	11,000	31,200	19,900	24,900	13,300	9,310	2,090
12.	6,950	5,530	7,660		9,510	17,000	8,950	33,000	16,500	24,900	10,100	15,000	4,580
13.	5,410	5,620	5,200		9,510	11,700	6,850	38,100	10,100	24,000	10,100	17,400	4,030
14.	5,410	4,210	4,590		7,910	11,300	11,000	35,100	10,100	24,000	8,350	10,700	4,700
15.	6,050	4,400	4,590		9,520	13,600	10,300	37,700	14,700	21,000	7,420	8,160	11,700
16.	6,490	7,420	4,590		6,490	11,700	9,520	37,700	20,600	21,000	8,350	5,200	8,420
17.	5,620	7,910	4,400		6,490	14,300	9,510	41,000	20,600	21,000	7,420	5,200	11,700
18.	4,590	10,100	4,400		10,700	17,000	11,000	41,800	43,800	29,900	10,100	8,420	8,420
19.	6,050	9,240	18,100		11,000	13,300	8,550	42,000	40,000	29,900	5,550	6,000	8,420
20.	5,620	11,300	11,000		7,180	8,760	8,250	43,100	40,000	29,900	5,550	3,170	7,180
21.	5,620	11,700	12,000		7,180	4,310	8,420	44,700	34,900	23,400	7,510	3,170	6,270
22.	5,530	8,690	11,700		8,950	10,400	8,420	42,000	31,200	24,500	7,510	4,480	6,270
23.	7,180	11,300	9,910		16,700	12,600	8,950	45,900	25,200	21,000	6,460	5,200	3,520
24.	4,630	9,240	9,910		18,100	14,700	8,950	45,900	22,900	17,400	12,000	3,850	6,460
25.	3,020	8,420	8,420		17,400	17,000	10,400	58,500	21,700	10,300	12,000	3,850	6,460
26.	4,400	8,160	23,600		17,000	34,800	5,620	53,900	21,000	10,300	12,000	3,850	6,460
27.	4,790	8,950	35,300		23,600	41,000	6,950	50,300	18,400	10,300	19,900	3,320	4,790
28.	5,620	7,420	32,000		40,000	33,000	16,000	45,900	12,600	10,300	17,400	4,800	5,620
29.	5,410	4,400	26,600		61,200	36,800	24,000	45,900	9,310	14,300	15,700	4,800	5,620
30.	6,490	7,180	19,900		57,200	-	33,600	-	13,000	12,000	10,700	5,200	8,420
31.	4,400	-	17,400		51,000	-	54,600	-	13,000	-	9,520	5,200	-

Norm. — Stage-discharge relation affected by ice from Dec. 14, 1915, to April 2, 1916; discharge estimates during this period based on gage heights, discharge measurements, weather records, information regarding ice conditions at Northampton, and comparison with records at Orford and Turners Falls.

Daily Discharge, in Second-feet, of Connecticut River at Sunderland, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.				1917.								
	Oct.	Nov.	Dec.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	14,300	6,950	26,400		4,590	6,270	15,700	41,400	23,300	19,900	10,100	3,330	11,300
2.	8,960	5,620	31,200		6,720	5,530	12,900	47,600	31,200	16,700	17,400	3,330	10,700
3.	10,100	5,330	29,600		6,490	6,270	9,910	47,000	35,300	22,600	17,000	4,210	10,700
4.	10,100	5,330	27,200		6,370	5,330	8,960	49,300	34,400	18,100	16,400	7,910	9,810
5.	8,960	5,200	32,600		6,720	3,330	5,300	51,400	32,400	18,100	11,000	2,780	9,230
6.	7,180	6,730	18,900		7,660	5,330	7,180	48,000	33,600	20,300	10,400	2,080	9,530
7.	6,050	6,950	18,900		7,660	5,630	6,270	45,000	33,200	19,300	10,400	4,030	8,690
8.	3,020	6,060	17,400		11,700	5,330	6,270	46,700	36,400	22,900	10,650	4,960	9,060
9.	3,410	5,620	17,400		10,400	5,200	6,720	46,300	37,200	27,100	7,910	4,400	4,400
10.	6,650	6,620	15,300		10,400	4,590	7,910	41,100	27,200	21,700	7,420	4,400	3,330
11.	6,620	6,490	14,800		8,960	2,450	6,490	33,600	25,000	23,300	6,270	6,060	4,400
12.	4,030	6,430	14,000		7,910	3,020	5,830	30,300	24,000	37,700	6,490	3,330	6,630
13.	4,960	6,460	13,300		7,180	5,200	8,160	26,300	24,000	49,900	6,270	6,200	4,790
14.	3,230	6,460	12,700		4,210	4,210	8,160	26,000	19,900	49,200	7,660	6,960	4,790
15.	3,020	6,950	11,700		11,700	4,400	9,810	28,000	24,000	44,300	4,790	6,200	4,210
16.	3,650	7,420	11,300		11,700	4,400	9,510	18,100	24,000	36,500	6,060	6,490	2,720
17.	6,050	7,420	8,960		12,300	4,400	8,690	21,000	22,500	30,800	7,910	6,490	3,560
18.	6,200	6,720	7,150		12,300	2,200	8,530	21,700	20,300	28,900	8,160	7,420	4,900
19.	6,050	3,330	9,520		11,000	1,950	8,690	24,300	17,900	39,000	7,660	10,700	4,790
20.	6,720	3,330	8,320		10,700	4,390	8,160	23,600	15,700	40,600	6,960	10,700	4,400
21.	10,400	6,620	8,320		7,420	4,400	5,160	25,000	17,800	36,100	6,960	12,600	4,210
22.	8,960	6,620	9,810		6,370	4,080	9,530	26,900	18,900	32,000	7,910	13,300	3,020
23.	10,100	6,200	7,420		7,910	4,030	10,100	26,900	20,300	28,000	6,200	13,000	1,690
24.	10,700	9,510	10,100		6,720	4,310	11,700	26,900	22,900	22,500	6,960	14,000	2,200
25.	6,960	22,500	11,300		6,490	2,200	35,700	44,300	23,100	22,500	6,960	14,000	3,300
26.	7,910	19,500	8,250		6,370	3,020	32,600	49,600	20,300	22,500	6,720	11,300	3,170
27.	6,850	14,700	9,240		6,060	6,960	39,400	44,700	19,900	18,900	7,180	16,000	3,330
28.	6,050	14,000	8,420		4,590	5,900	56,900	38,500	17,000	16,700	5,890	12,000	3,330
29.	4,210	13,300	10,100		5,200	14,000	60,600	38,000	19,800	14,700	3,020	10,400	3,020
30.	5,530	17,000	7,910		6,720	-	59,700	29,000	23,000	11,000	4,310	10,700	1,960
31.	6,950	-	6,410		5,830	-	46,700	-	23,000	-	-	11,700	-

NOTE. — Stage-discharge relation affected by ice December 15 to March 24; discharge during this period determined from study of gage-height graph, discharge measurements, weather records and comparison with similar study for Connecticut River at Orford.

Monthly Discharge of Connecticut River at Sunderland, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 8,000 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1915-16.					
October, ...	7,600	3,028	5,690	.711	.82
November, ...	11,700	3,500	7,200	.900	1.00
December, ...	35,300	4,400	11,600	1.450	1.67
January, ...	61,200	7,180	16,900	2.110	2.43
February, ...	47,000	4,210	21,900	2.740	2.96
March, ...	54,600	5,620	13,700	1.710	1.97
April, ...	70,100	31,200	46,000	5.780	6.42
May, ...	46,900	8,420	24,100	3.010	3.47
June, ...	29,600	12,600	20,400	2.550	2.84
July, ...	21,400	5,830	11,900	1.490	1.72
August, ...	17,400	2,320	6,370	.796	.92
September, ...	14,000	2,080	5,510	.689	.77
The year, ...	70,100	2,080	15,900	1.990	26.99
1916-17.					
October, ...	14,300	3,020	7,016	.876	1.01
November, ...	23,500	3,330	8,180	1.020	1.14
December, ...	31,200	5,410	14,000	1.750	2.02
January, ...	12,300	4,210	7,930	.991	1.14
February, ...	14,000	1,960	4,640	.580	.60
March, ...	60,800	5,300	17,400	2.180	2.51
April, ...	59,500	18,100	40,000	5.000	5.58
May, ...	35,300	15,700	24,600	3.080	3.55
June, ...	49,900	11,000	26,700	3.340	3.73
July, ...	17,400	3,020	7,930	.991	1.14
August, ...	16,000	2,060	8,020	1.000	1.15
September, ...	11,300	1,620	5,180	.648	.72
The year, ...	60,800	1,620	14,300	1.790	24.29

Millers River near Winchendon, Mass.

Location. — At the steel highway bridge known as Nolan's Bridge, about one-half mile below the mouth of Sip Pond Brook and 2 miles west of Winchendon.

Drainage Area. — Square miles, 80.0.

Records available. — June 5, 1916, to Sept. 30, 1917.

Gages. — Stevens continuous water-stage recorder on the right bank just below the highway bridge; installed and the record commenced July 4, 1917. Chain gage on down-stream side of bridge June 5, 1916, to Feb. 28, 1917. Foxborough water-stage recorder June 5 to July 3, 1917. Gages read by Arthur Lehman and Franklin Epps.

Discharge Measurements. — Made from the highway bridge or by wading.

Channel and Control. — Channel covered with gravel and alluvial deposits. Control for low and medium stages is about 200 feet below gage, and is clearly defined.

Extremes of Discharge. — Maximum stage recorded during the period June 5 to Sept. 30, 1916, 5.53 feet at 6 P.M. June 19 (approximate discharge by extension of rating curve, 677 second-feet); minimum stage recorded during period, 2.81 feet at 6 P.M. July 2, and 7 A.M. July 17 (approximate discharge by extension of rating curve, 14 second-feet).

Maximum stage during the year ending Sept. 30, 1917, occurred during the period of no gage-height record; minimum stage from water-stage recorder, 2.60 feet at 5.30 A.M. August 13 (discharge, about 6 second-feet).

Regulation. — The distribution of flow is affected by operation of power plants at Winchendon and by storage in Lake Monomac and other reservoirs.

Accuracy. — Stage-discharge relation probably permanent. Rating curve well defined below 250 second-feet, and fairly well defined between 250 and 600 second-feet. Chain gage read to hundredths twice daily. Daily discharge ascertained by applying mean daily gage heights to rating table June 5, 1916, to July 3, 1917. Mean daily gage height June 5, 1916, to Feb. 28, 1917, is mean of two observations per day. Mean daily gage height June 5 to July 3, 1917, is mean of 24 gage heights per day from water-stage recorder. Daily discharge July 4 to Sept. 30, 1917, determined by use of discharge integrator. Results good for period when the water-stage recorders were in operation. Remainder of results are fair.

*Discharge Measurements of Millers River near Winchendon, Mass., during
the Two-year Period ending Sept. 30, 1917.*

DATE.	Made by —	Gage Height (Feet).	Dis- charge (Second- feet).
1916.			
May 22, ...	Hardin Thweatt, ...	4.13	226.0
May 30, ...	Hardin Thweatt, ...	3.64	174.0
June 2, ...	Hardin Thweatt, ...	3.93	172.0
June 30, ...	Hardin Thweatt, ...	4.23	249.0
July 28, ...	Hardin Thweatt, ...	4.85	324.0
Aug. 8, ...	H. W. Fear, ...	3.74	137.0
Aug. 23, ...	H. W. Fear, ...	2.97	23.2
Aug. 23, ...	H. W. Fear, ...	2.98	24.0
Aug. 24, ...	H. W. Fear, ...	3.54	90.0
Oct. 13, ...	C. H. Pierce, ...	3.67	118.0
1917.			
Jan. 17, ...	Hardin Thweatt, ...	5.16 ¹	221.0
Feb. 20, ...	H. H. Khachadorian, ...	4.45 ¹	108.0
Apr. 3, ...	Hardin Thweatt, ...	5.34	462.0
Apr. 4, ...	Hardin Thweatt, ...	5.16	388.0
June 4, ...	Hardin Thweatt, ...	4.12	220.0
June 4, ...	Hardin Thweatt, ...	4.12	220.0
June 11, ...	Hardin Thweatt, ...	4.44	257.0
June 12, ...	Hardin Thweatt, ...	4.77	342.0
June 15, ...	C. H. Pierce, ...	3.90	179.0
June 18, ...	Hardin Thweatt, ...	5.67	480.0
June 18, ...	M. R. Stackpole, ...	5.58	505.0

¹ Stage-discharge relation affected by ice.

*Daily Discharge, in Second-feet, of Miller's River near Winchendon, Mass.,
for the Year ending Sept. 30, 1916.*

DAY.	June.	July.	Aug.	Sept.
1, ...	-	54	87	88
2, ...	-	14	83	47
3, ...	-	133	80	26
4, ...	-	97	101	21
5, ...	135	205	37	43
6, ...	126	123	28	68
7, ...	123	135	76	64
8, ...	90	89	86	55
9, ...	126	35	76	40
10, ...	133	97	74	21
11, ...	186	178	58	45
12, ...	336	105	56	61
13, ...	334	99	31	67
14, ...	300	93	53	54
15, ...	242	64	109	125
16, ...	192	15	73	224
17, ...	314	78	69	68
18, ...	246	76	52	159
19, ...	333	67	27	192
20, ...	280	51	26	169
21, ...	170	48	33	74
22, ...	272	39	37	64
23, ...	200	40	45	165
24, ...	95	111	70	159
25, ...	97	53	29	269
26, ...	272	82	41	199
27, ...	212	178	18	86
28, ...	182	312	48	79
29, ...	137	212	39	93
30, ...	117	79	73	183
31, ...	-	150	97	-

*Daily Discharge, in Second-feet, of Millers River near Winchendon, Mass.,
for the Year ending Sept. 30, 1917.*

DAY.	1916.			1917.					
	Oct.	Nov.	Dec.	Jan.	Feb.	June.	July.	Aug.	Sept.
1, . . .	111	88	105	54	50	-	107	56	305
2, . . .	129	45	218	84	25	-	103	47	130
3, . . .	101	31	53	125	45	-	103	44	65
4, . . .	82	34	55	135	18	-	38	39	144
5, . . .	62	16	78	135	40	45	63	14	61
6, . . .	70	31	53	115	62	76	66	37	70
7, . . .	54	58	53	27	78	129	58	62	68
8, . . .	29	61	82	93	55	125	17	59	65
9, . . .	53	53	109	125	62	79	47	76	25
10, . . .	58	53	31	125	35	61	73	88	65
11, . . .	67	35	47	121	25	131	77	64	65
12, . . .	64	24	53	105	55	248	114	19	72
13, . . .	67	42	76	85	55	274	61	42	70
14, . . .	45	61	51	50	70	252	90	63	62
15, . . .	16	78	76	125	62	175	17	65	58
16, . . .	55	47	73	170	145	125	66	104	17
17, . . .	42	53	39	78	105	284	63	210	69
18, . . .	49	41	53	70	25	475	94	315	62
19, . . .	51	27	76	70	95	405	82	174	69
20, . . .	76	40	56	70	85	327	100	186	62
21, . . .	41	43	89	25	40	246	70	146	86
22, . . .	29	39	76	40	22	143	13	114	43
23, . . .	73	39	117	78	45	115	76	92	15
24, . . .	78	76	47	45	25	109	76	89	58
25, . . .	70	105	95	50	16	180	106	65	60
26, . . .	66	53	125	45	62	178	116	36	54
27, . . .	51	93	125	35	78	160	113	87	52
28, . . .	33	99	125	18	240	66	66	72	49
29, . . .	21	82	115	40	-	78	21	190	34
30, . . .	35	101	105	45	-	80	70	340	17
31, . . .	55	-	32	62	-	-	83	340	-

NOTE. — Stage-discharge relation affected by ice December 26 to 30, and January 3 to February 28; discharge for these periods determined from study of gage-height graph, discharge measurements, weather records and comparison with similar study for Millers River at Erving. No gage-height record March 1 to June 4. Discharge September 6 estimated by comparison with Sip Pond Brook near Winchendon.

Monthly Discharge of Millers River near Winchendon, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 80.0 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1916.					
June 5 to 30, ...	383	89	204.0	2.550	2.46
July, ...	312	14	100.0	1.250	1.44
August, ...	109	18	57.8	.722	.83
September, ...	300	21	95.1	1.190	1.33
1916-17.					
October, ...	129	16	59.2	.740	.85
November, ...	105	16	53.8	.672	.75
December, ...	218	31	80.3	1.000	1.15
January, ...	170	18	78.9	.986	1.14
February, ...	240	18	61.4	.768	.80
June 5 to 30, ...	475	45	176.0	2.200	2.13
July, ...	118	17	72.8	.910	1.05
August, ...	340	14	108.0	1.350	1.54
September, ...	305	15	69.2	.865	.97

Millers River at Erving, Mass.

Location. — At down-stream end of chair factory at Erving, about 8 miles above the confluence of Millers River with Connecticut River, and below all important tributaries.

Drainage Area. — Square miles, 372.

Records available. — Aug. 1, 1914, to Sept. 30, 1917.

Gages. — Vertical staff attached to down-stream end of factory; read by C. H. Gary, E. F. Bancroft and Arthur Lemire. Automatic water-stage recorder installed in gage house on right bank July 1, 1915; gage heights referenced to gage datum by a hook gage inside the well.

Discharge Measurements. — Made from cable or by wading.

Channel and Control. — Channel covered with coarse gravel and boulders; control section is a short distance below the gage and is practically permanent.

Extremes of Discharge. — Maximum stage during year ending Sept. 30, 1916, from water-stage recorder, 4.95 feet at 8.15 A.M.

April 2 (discharge, 3,830 second-feet); minimum stage during year from water-stage recorder, 0.95 foot at noon December 14 (discharge, 4.5 second-feet).

Maximum stage during year ending Sept. 30, 1917, from water-stage recorder, 4.32 feet at 6 P.M. March 28 (discharge, 2,460 second-feet); minimum stage during year from water-stage recorder, 0.87 foot at 3.30 P.M. October 29 (discharge practically zero).

Maximum stage recorded, 1914-17, 5.6 feet at 4 P.M. Feb. 25, 1915 (discharge, 5,160 second-feet); minimum stage, practically no flow at various times during 1915, and at 3.30 P.M. Oct. 29, 1916, water being held back by dams above the gage.

Ice. — River freezes over below the gage at various times during the winter; ice considerably broken by rising and falling stages due to power operation.

Regulation. — Distribution of flow affected by operation of various power plants and storage reservoirs above the station.

Accuracy. — Stage-discharge relation practically permanent except during ice periods. Rating curve well defined below 4,000 second-feet. Staff gage read to hundredths twice daily. Daily discharge ascertained by applying mean daily gage heights from water-stage recorder to rating table. For periods when continuous gage-height record was not obtained the staff gage records were used with corrections as determined by various comparisons with the water-stage recorder. Results good, except for times of ice effect, when they are fair.

Discharge Measurements of Millers River at Erving, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
1915.			
Oct. 3, ...	Hardin Thweatt, ...	1.59	94
Dec. 30, ...	Hardin Thweatt, ...	3.61	1,440
Dec. 31, ...	Hardin Thweatt, ...	3.63 ¹	1,300
1916.			
Jan. 6, ...	Hardin Thweatt, ...	3.15	907
Jan. 7, ...	Hardin Thweatt, ...	3.29	969
Jan. 7, ...	Hardin Thweatt, ...	3.25	908
Jan. 21, ...	Pierce and Barnes, ...	3.20 ²	535
Feb. 2, ...	R. S. Barnes, ...	3.85	1,670
Feb. 2, ...	R. S. Barnes, ...	3.68	1,490
Feb. 3, ...	R. S. Barnes, ...	3.46	1,200
Feb. 3, ...	R. S. Barnes, ...	3.45	1,200
Mar. 20, ...	Hardin Thweatt, ...	2.92	729
Mar. 21, ...	Hardin Thweatt, ...	3.04	819
Apr. 2, ...	Hardin Thweatt, ...	4.96	3,550
Apr. 3, ...	Hardin Thweatt, ...	4.94	3,520
Apr. 5, ...	Hardin Thweatt, ...	4.33	2,530
Apr. 6, ...	Hardin Thweatt, ...	4.24	2,220
Apr. 6, ...	Hardin Thweatt, ...	4.14	2,110
Aug. 10, ...	Hardin Thweatt, ...	2.60	444
Dec. 8, ...	A. H. Davison, ...	2.03	365
Dec. 19, ...	Hardin Thweatt, ...	2.38 ¹	324
1917.			
Jan. 20, ...	Hardin Thweatt, ...	3.55 ¹	710
Jan. 30, ...	Hardin Thweatt, ...	2.72 ¹	344
Feb. 23, ...	H. H. Khachadoorian, ...	3.76 ¹	509
Sept. 18, ...	M. R. Stackpole, ...	2.21	319

¹ Some anchor ice in channel; stage-discharge relation possibly affected.

² Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Millers River at Erving, Mass., for the Year ending Sept. 30, 1918.

Day.	1915.			1916.									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	
1.	224	252	280	1,250	1,240	2,240	3,590	1,350	618	540	684	360	
2.	176	187	253	812	1,300	1,720	3,710	1,150	538	428	534	264	
3.	147	190	268	832	1,130	1,340	2,470	1,010	480	396	504	166	
4.	805	190	230	941	1,060	1,180	2,920	960	450	618	356	160	
5.	213	260	101	708	960	960	2,430	932	435	658	378	238	
6.	355	292	244	740	700	941	2,160	828	644	716	300	236	
7.	313	44	213	836	700	844	1,890	672	686	606	335	205	
8.	350	166	220	1,050	950	708	1,690	772	672	522	276	244	
9.	273	180	236	1,230	860	788	1,490	844	612	528	492	240	
10.	223	198	240	1,850	630	724	1,450	852	700	528	436	116	
11.	264	190	232	1,030	630	679	1,540	756	878	528	344	205	
12.	248	191	63	890	510	696	1,760	651	1,190	558	380	205	
13.	256	173	273	724	610	672	1,910	612	1,120	445	310	220	
14.	228	41	202	794	630	693	1,910	425	923	474	340	183	
15.	243	240	288	700	630	883	1,990	510	852	390	335	300	
16.	355	256	430	570	570	568	1,840	532	740	280	310	1,120	
17.	141	268	456	700	450	740	1,800	800	941	345	330	1,030	
18.	276	240	450	570	510	923	1,720	1,000	1,320	320	272	780	
19.	410	280	700	510	510	672	1,450	1,300	1,470	370	190	796	
20.	325	540	852	510	450	658	1,380	1,390	1,440	300	81	700	
21.	310	440	860	450	450	618	1,240	1,020	1,260	355	272	498	
22.	293	365	960	510	450	564	1,170	1,050	1,120	410	288	410	
23.	330	350	796	1,050	450	606	1,590	900	900	252	202	480	
24.	48	335	748	860	510	716	1,910	905	686	445	292	828	
25.	260	248	644	846	610	606	2,070	820	570	486	445	869	
26.	202	284	1,220	914	2,710	644	1,780	685	905	510	340	748	
27.	198	248	2,410	1,150	2,920	764	1,680	679	900	1,000	198	606	
28.	194	187	1,550	1,540	3,240	1,370	1,470	480	820	1,520	375	515	
29.	209	236	1,560	1,630	2,920	1,630	1,480	570	693	1,410	380	420	
30.	205	240	1,260	1,270	-	2,240	1,390	510	522	1,040	405	700	
31.	74	-	1,220	1,250	-	3,360	-	570	-	780	360	-	

NOTE. — Stage-discharge relation affected by ice January 15 to 24, and February 4 to 25, 1916; discharge estimates during these periods based on gage heights, one discharge measurement, observer's notes regarding ice conditions, and weather records.

Daily Discharge, in Second-feet, of Millers River at Erving, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.				1917.							
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	700	550	1,080	440	390	1,550	2,350	880	780	560	260	1,140
2.	650	530	1,080	310	360	1,500	2,200	960	700	630	210	900
3.	600	500	900	380	320	1,250	2,050	1,140	610	490	240	570
4.	510	235	820	390	310	1,100	1,900	1,020	640	320	220	490
5.	420	155	660	460	300	1,000	1,720	1,000	520	410	83	430
6.	410	135	600	530	320	1,060	1,650	1,200	620	375	250	370
7.	350	340	570	550	290	880	1,840	1,360	680	360	210	320
8.	310	320	520	570	300	780	1,920	1,160	840	255	160	315
9.	265	350	410	740	300	780	1,750	1,140	850	315	240	315
10.	300	320	470	660	320	720	1,580	1,020	710	275	620	295
11.	300	290	450	600	260	610	1,340	860	780	365	520	315
12.	320	255	460	590	290	730	1,230	820	1,280	450	280	290
13.	345	275	490	460	290	870	1,260	680	1,520	530	375	270
14.	410	230	480	460	280	920	1,020	740	1,300	410	240	275
15.	400	115	450	1,150	270	770	840	750	1,180	330	270	240
16.	315	190	400	900	300	810	900	720	930	365	280	120
17.	320	170	400	940	300	890	890	610	930	340	340	575
18.	300	300	350	700	300	860	880	560	1,400	470	740	525
19.	310	95	370	520	320	1,020	980	460	1,380	470	800	260
20.	415	325	370	490	300	860	980	465	1,240	435	700	245
21.	460	300	360	500	300	820	1,150	570	880	420	510	265
22.	330	290	390	450	280	820	1,080	445	780	300	540	275
23.	330	320	390	450	280	1,020	1,140	670	600	260	440	96
24.	375	360	390	480	270	1,660	1,100	850	430	315	360	270
25.	320	390	390	450	300	2,200	1,040	880	680	390	345	315
26.	340	360	340	450	300	2,800	770	570	600	420	260	200
27.	320	390	310	470	450	3,000	930	570	550	395	375	188
28.	300	370	520	500	1,300	3,350	890	450	540	360	325	240
29.	115	540	530	370	-	4,500	810	860	410	265	380	245
30.	260	660	460	340	-	3,460	760	1,080	540	265	850	63
31.	280	-	450	370	-	2,600	-	980	-	210	1,280	-

NOTE. — Stage-discharge relation affected by ice December 16 to 27, December 30 to January 1, and January 11 to March 10; discharge for these periods determined from study of stage-height graph, discharge measurements, weather records and comparison with similar study for Millers River near Winchendon.

*Monthly Discharge of Millers River at Erving, Mass., for the Two-year
Period ending Sept. 30, 1917.*

[Drainage area, 372 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1915-16.					
October, ...	410	48	243	.653	.75
November, ...	540	41	244	.656	.73
December, ...	2,410	63	633	1.700	1.96
January, ...	1,850	450	922	2.480	2.86
February, ...	3,240	450	1,000	2.690	2.90
March, ...	3,360	558	1,010	2.720	3.14
April, ...	3,710	1,170	1,980	5.190	5.79
May, ...	1,990	425	878	2.360	2.72
June, ...	1,470	435	842	2.260	2.52
July, ...	1,520	252	570	1.530	1.76
August, ...	686	81	380	.941	1.08
September, ...	1,120	116	485	1.250	1.40
The year, ...	3,710	41	755	2.080	27.61
1916-17.					
October, ...	700	90	359	.965	1.11
November, ...	800	95	365	.981	1.09
December, ...	1,080	360	557	1.500	1.73
January, ...	1,150	310	548	1.470	1.70
February, ...	1,200	200	351	.944	.98
March, ...	4,500	610	1,490	4.010	4.62
April, ...	2,350	760	1,290	3.470	3.87
May, ...	1,360	445	829	2.230	2.57
June, ...	1,520	410	830	2.230	2.49
July, ...	630	210	383	1.030	1.19
August, ...	1,280	82	407	1.090	1.26
September, ...	1,140	63	320	.860	.96
The year, ...	4,500	63	646	1.740	23.57

Sip Pond Brook near Winchendon, Mass.

Location. — About 50 feet above highway bridge, one-fourth mile below the Massachusetts-New Hampshire State line, $1\frac{1}{2}$ miles below the outlet of Sip Pond, and 3 miles northwest of Winchendon.

Drainage Area. — Square miles, 18.8.

Records available. — May 29, 1916, to Sept. 30, 1917.

Gages. — Gurley seven-day water-stage recorder on the right bank, installed June 26, 1917. Sloping staff gage on right bank, installed May 29, 1916. Stevens 8-day water-stage recorder June 30 to Dec. 12, 1916. Gages read by W. G. Greenall and Hazel Greenall.

Discharge Measurements. — Made by wading.

Channel and Control. — Channel rough and covered with boulders immediately above and below the gages. Control clearly defined. Considerable aquatic vegetation in the channel during summer months.

Extremes of Discharge. — Maximum stage recorded during the period May 29 to Sept. 30, 1916, 3.71 feet at 4 P.M. July 28 (approximate discharge by extension of rating curve, 82 second-feet); minimum stage recorded during period, 1.91 feet at 10 P.M. September 10 (approximate discharge by extension of rating curve, 5 second-feet).

Maximum stage during year ending Sept. 30, 1917, occurred during period of no gage-height record; minimum stage from water-stage recorder, 5.1 feet at 6 P.M. August 5 (discharge, about 8 second-feet).

Regulation. — The distribution of flow is considerably affected by operation of mills at State Line, New Hampshire, and by storage in Pearly Pond and Sip Pond.

Accuracy. — Stage-discharge relation changes occasionally. Rating curves used May 29, 1916, to June 26, 1917, fairly well defined between 9 and 60 second-feet. Rating curve used June 27 to Sept. 30, 1917, well defined between 10 and 100 second-feet. Sloping staff gage read to hundredths twice daily. Operation of water-stage recorders satisfactory. Daily discharge May 29, 1916, to June 26, 1917, ascertained by applying mean daily gage heights to rating table. Daily discharge June 27 to Sept. 30, 1917, determined by use of discharge integrator. Results good.

*Discharge Measurements of Sip Pond Brook near Winchendon, Mass., during
the Two-year Period ending Sept. 30, 1917.*

DATE.	Made by —	Vertical Gage Height.	Inclined Gage Height (Feet).	Dis- charge (Second- feet).
1916.				
May 22, ...	Hardin Thweatt, ...	-	2.99	51.0
May 30, ...	Hardin Thweatt, ...	-	2.22	16.6
June 2, ...	Hardin Thweatt, ...	-	2.32	20.9
June 30, ...	Hardin Thweatt, ...	-	2.45	22.8
July 24, ...	Hardin Thweatt, ...	-	2.40	20.7
Aug. 8, ...	H. W. Fear, ...	-	2.30	16.5
Aug. 8, ...	Hardin Thweatt, ...	-	2.36	18.1
Aug. 24, ...	H. W. Fear, ...	-	2.11	9.8
Sept. 17, ...	Hardin Thweatt, ...	-	2.62	28.7
1917.				
Oct. 14, ...	C. H. Pierce, ...	-	2.23	12.8
Nov. 7, ...	Hardin Thweatt, ...	-	2.56	25.5
Dec. 21, ...	Hardin Thweatt, ...	-	2.72	36.0
Jan. 18, ...	H. H. Khachadoorian, ...	-	3.05	56.4
Feb. 21, ...	H. H. Khachadoorian, ...	-	4.22 ¹	33.0
April 3, ...	Hardin Thweatt, ...	-	3.86	116.0
April 3, ...	Hardin Thweatt, ...	-	3.90	120.0
June 3, ...	Hardin Thweatt, ...	-	2.46	22.5
June 3, ...	Hardin Thweatt, ...	-	2.50	25.6
June 9, ...	Hardin Thweatt, ...	6.47	2.93	43.4
June 12, ...	Hardin Thweatt, ...	-	3.35 ²	64.0
June 13, ...	C. H. Pierce, ...	6.95	3.45	80.0
June 21, ...	C. H. Pierce, ...	6.55	3.05	53.0
July 5, ...	Hardin Thweatt, ...	5.93	2.45	23.7
July 7, ...	M. R. Stackpole, ...	5.46	2.06	11.7

¹ Stage-discharge relation affected by ice.

² Results uncertain.

*Daily Discharge, in Second-feet, of Sip Pond Brook near Winchendon, Mass.,
for the Year ending Sept. 30, 1916.*

DAY.	May.	June.	July.	Aug.	Sept.
1, ...	-	22	16	28	11
2, ...	-	26	14	25	12
3, ...	-	18	22	22	8.5
4, ...	-	14	22	19	7.5
5, ...	-	24	28	20	12
6, ...	-	25	20	12	12
7, ...	-	24	24	16	10
8, ...	-	22	17	20	6.8
9, ...	-	22	19	22	12
10, ...	-	25	24	20	5.6
11, ...	-	50	18	16	10
12, ...	-	57	18	12	10
13, ...	-	52	20	10	9.2
14, ...	-	53	16	15	8.2
15, ...	-	43	12	16	16
16, ...	-	40	7.8	16	35
17, ...	-	42	12	15	30
18, ...	-	56	12	14	44
19, ...	-	67	12	15	42
20, ...	-	69	9.7	8	32
21, ...	-	65	12	14	29
22, ...	-	55	14	13	25
23, ...	-	46	10	15	29
24, ...	-	30	16	18	53
25, ...	-	34	14	15	63
26, ...	-	46	18	12	50
27, ...	-	42	26	8.8	32
28, ...	-	38	78	16	29
29, ...	30	31	68	19	28
30, ...	26	21	54	16	44
31, ...	30	-	42	11	-

NOTE. — Daily discharge based on twice-daily reading of sloping staff gage for the following periods: May 29 to June 29, July 28 to 31, and September 25 to 27; for all other days water-staff recorder was used.

Daily Discharge, in Second-feet, of Sip Pond Brook near Winchendon, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	
1.	61	15	56	30	17	62	120	48	36	19	14	100	
2.	58	13	55	27	17	68	124	60	34	24	14	76	
3.	50	30	48	24	17	69	121	68	26	24	14	66	
4.	33	18	44	18	9	51	109	52	30	20	14	51	
5.	31	10	34	28	15	48	101	61	34	30	18	38	
6.	25	19	37	40	17	50	103	63	32	18	15	35	
7.	24	7.	35	24	15	44	120	61	36	16	11	33	
8.	15	20	28	30	18	43	114	65	36	11	13	28	
9.	22	16	21	35	15	43	112	54	40	15	13	24	
10.	22	18	12	32	15	42	98	51	37	19	14	27	
11.	20	15	20	33	7	26	74	48	57	18	10	22	
12.	20	8	24	34	15	39	60	42	74	18	15	21	
13.	18	18	26	32	15	37	60	42	68	16	14	18	
14.	8	18	24	18	15	38	58	42	63	16	14	16	
15.	25	20	29	46	15	38	54	36	44	15	45	45	
16.	15	20	16	57	15	39	44	30	68	17	136	14	
17.	18	18	26	47	7	31	42	27	86	18	176	15	
18.	17	10	29	39	16	41	42	26	77	21	136	14	
19.	24	16	31	32	21	53	46	19	56	13	70	15	
20.	11	19	25	20	17	49	68	26	48	16	63	14	
21.	13	18	30	17	14	37	58	24	38	10	55	13	
22.	21	30	26	21	17	38	70	26	34	14	43	11	
23.	24	20	14	20	18	51	60	29	29	22	39	14	
24.	19	19	19	19	7	61	55	34	37	24	32	14	
25.	32	19	26	18	39	96	51	34	32	23	28	13	
26.	14	19	26	18	39	117	51	34	27	24	28	14	
27.	17	30	29	19	46	146	54	30	27	20	24	15	
28.	14	30	30	9	46	290	48	36	24	13	35	15	
29.	9	28	30	18	-	237	46	36	21	17	112	10	
30.	17	31	29	20	-	202	43	36	23	17	128	-	
31.	17	-	18	21	-	152	-	38	-	-	-	-	

NOTE. — Stage-discharge relation affected by ice December 26 to January 5, and January 11 to 15, and January 19 to March 9; discharge for these periods determined from study of gage-height graph, observer's notes and weather records.

*Monthly Discharge of Sip Pond Brook near Winchendon, Mass., for the
Two-year Period ending Sept. 30, 1917.*

[Drainage area, 18.8 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1916.					
May 29 to 31, ...	30	26.0	28.7	1.530	.17
June, ...	69	14.0	38.6	2.050	2.29
July, ...	78	7.8	23.4	1.240	1.43
August, ...	28	8.0	16.1	.886	.90
September, ...	63	5.6	17.2	.915	1.02
1916-17.					
October, ...	61	8.0	21.8	1.160	1.34
November, ...	32	9.0	19.2	1.020	1.14
December, ...	56	12.0	28.8	1.530	1.76
January, ...	57	9.0	27.6	1.470	1.70
February, ...	60	7.0	18.4	.979	1.02
March, ...	290	26.0	74.7	8.970	4.53
April, ...	124	42.0	74.8	3.980	4.44
May, ...	63	10.0	41.2	2.190	2.32
June, ...	86	21.0	42.6	2.270	2.33
July, ...	24	10.0	17.7	.941	1.06
August, ...	176	9.0	43.5	2.310	2.96
September, ...	100	10.0	26.1	1.390	1.35
The year, ...	290	7.0	36.5	1.940	26.32

Priest Brook near Winchendon, Mass.

Location. — At highway bridge 3 miles above confluence of Priest Brook with Millers River and $3\frac{1}{2}$ miles west of Winchendon.

Drainage Area. — Square miles, 18.8.

Records available. — May 25, 1916, to Sept. 30, 1917.

Gage. — Sloping staff on left bank 200 feet below highway bridge; read by R. D. Hutchinson.

Discharge Measurements. — Made from highway bridge or by wading.

Channel and Control. — Channel above the station is straight, with fairly uniform section and gravel bottom. Control is formed

by the foundation of an old dam 30 feet below the gage, and is permanent.

Extremes of Discharge. — Maximum stage recorded during the period May 25 to Sept. 30, 1916, 4.26 feet at 7 P.M. July 27 (discharge, 176 second-feet); minimum stage recorded during period, 2.40 feet at 7 P.M. September 11, 7 A.M. and 7 P.M. September 14, and at 7 A.M. September 15 (approximate discharge by extension of rating curve, 2.0 second-feet).

Maximum stage recorded during year ending Sept. 30, 1917, 4.88 feet at 7 A.M. March 28 and 29 (discharge, 306 second-feet); minimum stage recorded during year, 2.30 feet several times in August (discharge, about 1.5 second-feet).

Regulation. — Flow not appreciably affected by regulation.

Accuracy. — Stage-discharge relation permanent. Rating curve well defined between 5 and 180 second-feet. Gage read to hundredths twice daily. Daily discharge ascertained by applying mean daily gage heights to rating table. Results good.

Discharge Measurements of Priest Brook near Winchendon, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
1916.			
May 22, ...	Hardin Thweatt, ...	3.23	33.90
May 30, ...	Hardin Thweatt, ...	3.11	25.60
June 2, ...	Hardin Thweatt, ...	3.09	25.60
June 30, ...	Hardin Thweatt, ...	2.99	20.40
July 28, ...	Hardin Thweatt, ...	4.18	161.00
Aug. 8, ...	H. W. Fear, ...	2.66	6.10
Aug. 24, ...	H. W. Fear, ...	3.08	27.00
Sept. 18, ...	Hardin Thweatt, ...	3.56	65.00
Dec. 22, ...	Hardin Thweatt, ...	3.00 ¹	17.60
1917.			
Jan. 17, ...	Hardin Thweatt, ...	3.53 ¹	45.80
Feb. 20, ...	H. H. Khachadorian, ...	2.85	—
April 3, ...	Hardin Thweatt, ...	4.04	138.00
June 9, ...	C. H. Pierce, ...	3.37	49.00
June 8, ...	Hardin Thweatt, ...	3.40	50.00
Aug. 2, ...	M. R. Stackpole, ...	2.37	2.58

¹ Stage-discharge relation affected by ice.

*Daily Discharge, in Second-feet, of Priest Brook near Winchendon, Mass.,
for the Year ending Sept. 30, 1916.*

DAY.	May.	June.	July.	Aug.	Sept.
1, ...	-	26	18	29	6.2
2, ...	-	24	17	21	7.7
3, ...	-	16	30	18	2.6
4, ...	-	32	50	29	2.5
5, ...	-	29	47	19	2.6
6, ...	-	24	35	19	4.2
7, ...	-	34	35	8.6	11
8, ...	-	30	20	4.8	5.6
9, ...	-	27	21	25	10
10, ...	-	30	21	27	3.8
11, ...	-	61	27	17	2.1
12, ...	-	37	21	15	3.4
13, ...	-	50	17	13	4
14, ...	-	43	19	16	2
15, ...	-	33	17	18	8
16, ...	-	29	16	11	129
17, ...	-	41	15	9.5	65
18, ...	-	73	15	8	60
19, ...	-	77	15	6.8	52
20, ...	-	81	11	14	42
21, ...	-	75	15	5	35
22, ...	-	65	15	3	32
23, ...	-	48	22	9.5	36
24, ...	-	39	19	22	95
25, ...	35	33	19	11	65
26, ...	28	53	20	11	49
27, ...	24	48	88	3	40
28, ...	18	32	150	13	32
29, ...	20	26	77	15	32
30, ...	27	21	43	9.8	59
31, ...	35	-	35	9.2	-

Daily Discharge, in Second-feet, of Priest Brook near Winchendon, Mass., for the Year ending Sept. 30, 1917.

Day.		1917.											
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	.	54	23	52	12	12	80	150	29	35	13	2.4	132
2.	.	49	18	71	17	12	83	150	50	25	11	2.4	99
3.	.	33	16	36	19	12	82	150	42	26	11	0.5	66
4.	.	25	16	45	20	13	50	132	46	29	11	2.5	55
5.	.	23	19	41	24	10	40	122	46	25	12	2	38
6.	.	22	21	46	22	10	35	112	50	29	16	1.6	32
7.	.	20	17	41	22	10	35	150	51	32	8	1.7	21
8.	.	17	14	49	26	10	32	150	50	44	8	2	20
9.	.	13	16	48	36	8.4	32	112	37	40	9.5	2.8	20
10.	.	14	16	30	39	8	34	91	36	39	9.8	32	19
11.	.	14	19	26	36	8	30	52	37	33	13	7.4	18
12.	.	14	13	24	32	7.1	32	50	38	64	23	2.2	9.2
13.	.	13	15	21	35	6.5	32	70	39	122	21	0.5	9.5
14.	.	13	15	20	31	6.5	39	45	35	102	11	8.3	17
15.	.	13	19	20	31	6.8	32	45	37	71	7.1	14	11
16.	.	13	18	20	44	6.8	32	45	32	86	13	41	8.3
17.	.	15	16	16	35	8	32	45	22	67	13	150	7.7
18.	.	19	19	14	35	8	32	45	22	82	15	109	13
19.	.	13	13	13	29	7.1	42	33	20	91	15	66	6
20.	.	32	13	13	24	12	35	42	16	91	15	31	11
21.	.	32	22	14	14	7.7	35	33	17	36	13	33	8.6
22.	.	25	17	22	17	5.3	35	33	21	36	13	34	8
23.	.	23	13	29	16	10	39	69	23	24	8	31	9
24.	.	23	32	36	15	12	52	42	39	22	6.5	23	7.5
25.	.	23	31	31	11	13	168	52	34	27	27	23	7
26.	.	21	58	31	10	14	158	54	34	25	16	19	6.5
27.	.	17	34	27	15	21	248	53	16	20	13	17	6.5
28.	.	16	38	27	12	54	259	32	19	26	8.9	8.6	6.5
29.	.	19	29	26	12	—	233	32	55	23	6.3	29	2.8
30.	.	15	24	22	16	—	246	29	67	30	4.6	109	2.5
31.	.	15	—	21	16	—	168	—	42	—	3.4	—	—

NOTE. — Stage-discharge relation affected by ice December 13 to 29, and January 12 to February 27; discharge for these periods determined from study of gage-height graph, discharge measurements and weather records.

Monthly Discharge of Priest Brook near Winchendon, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 18.8 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1916.					
May 25 to 31, ...	35	18.0	26.7	1.420	.37
June, ...	81	16.0	41.2	2.190	2.44
July, ...	150	11.0	31.3	1.660	1.91
August, ...	29	3.0	14.2	.755	.67
September, ...	129	2.0	30.0	1.600	1.78
1916-17.					
October, ...	54	12.0	21.4	1.140	1.31
November, ...	82	13.0	23.6	1.260	1.41
December, ...	71	13.0	30.1	1.600	1.84
January, ...	64	10.0	24.9	1.320	1.32
February, ...	54	5.3	11.8	.628	.66
March, ...	299	29.0	84.1	4.470	5.15
April, ...	150	26.0	74.9	3.980	4.44
May, ...	61	16.0	35.6	1.890	2.13
June, ...	122	20.0	47.3	2.520	2.81
July, ...	27	3.4	11.9	.633	.73
August, ...	206	1.6	39.9	2.120	2.44
September, ...	132	2.5	22.3	1.190	1.33
The year, ...	299	1.6	35.8	1.900	25.81

Otter River near Gardner, Mass.

Location. — At concrete arch bridge just above outlet of Wilder and Kneeland brooks, about 1 mile west of West Gardner.

Drainage Area. — Square miles, 20.0.

Records available. — June 29, 1916, to Sept. 30, 1917.

Gage. — Vertical staff bolted to down-stream side of highway culvert; read by Alfred Cavalier.

Discharge Measurements. — Made from bridge or by wading.

Channel and Control. — The growth of aquatic vegetation in the channel during the summer months seriously affects the control.

Extremes of Discharge. — Maximum stage recorded during the period June 29 to Sept. 30, 1916, 2.24 feet at 6.30 A.M. July 28 (discharge, 50 second-feet); minimum stage recorded during

period, 0.68 foot at 6.30 P.M. August 17 (discharge, 8.6 second-foot).

Maximum stage recorded during year ending Sept. 30, 1917, 3.60 feet at 6 P.M. March 28 (discharge, 189 second-foot); minimum stage recorded during year, 0.0 feet several times in September (discharge, about 5 second-foot).

Regulation. — The operation of a filter plant one-fourth mile above the gage causes occasional fluctuations in discharge.

Accuracy. — Stage-discharge relation seriously affected by ice and the growth of aquatic vegetation, and frequent discharge measurements are required. The form of the standard curve is fairly well defined. Gage read to hundredths twice daily. Daily discharge ascertained by method of shifting control, applying corrected gage heights to rating table for the standard curve. Results fair.

Discharge Measurements of Otter River near Gardner, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-foot).
1916.			
June 28, ...	Hardin Thweatt, ...	1.61	48.2
July 28, ...	Hardin Thweatt, ...	2.20	47.5
Aug. 9, ...	Hardin Thweatt, ...	1.33	23.0
Aug. 9, ...	H. W. Fear, ...	1.33	23.0
Aug. 22, ...	H. W. Fear, ...	1.00	13.1
Aug. 26, ...	H. W. Fear, ...	1.21	20.4
Sept. 18, ...	Hardin Thweatt, ...	1.24	16.9
Oct. 14, ...	C. H. Pierce, ...	.44	5.8
Nov. 8, ...	Hardin Thweatt, ...	.32	11.4
Dec. 21, ...	Hardin Thweatt, ...	.29	8.6
1917.			
Jan. 13, ...	Hardin Thweatt, ...	1.75	31.0
Feb. 22, ...	H. H. Khachadorian, ...	.64	15.5
Apr. 4, ...	Hardin Thweatt, ...	1.67	88.0
Apr. 4, ...	Hardin Thweatt, ...	1.67	92.0
June 4, ...	Hardin Thweatt, ...	1.75	39.5
June 14, ...	C. H. Pierce, ...	2.02	71.0
June 28, ...	Hardin Thweatt, ...	1.85	34.0
June 28, ...	M. R. Stackpole, ...	1.84	34.8
Aug. 1, ...	M. R. Stackpole, ...	.71	15.6
Sept. 10, ...	M. R. Stackpole, ...	1.03	6.7

*Daily Discharge, in Second-feet, of Otter River near Gardner, Mass., for the
Year ending Sept. 30, 1916.*

DAY.	June.	July.	Aug.	Sept.
1, ...	-	35	30	18
2, ...	-	30	31	16
3, ...	-	30	25	19
4, ...	-	40	23	17
5, ...	-	38	20	15
6, ...	-	42	19	14
7, ...	-	37	17	12
8, ...	-	30	19	16
9, ...	-	25	23	17
10, ...	-	23	22	15
11, ...	-	33	23	13
12, ...	-	38	17	15
13, ...	-	35	15	12
14, ...	-	30	15	11
15, ...	-	20	19	10
16, ...	-	28	18	16
17, ...	-	25	9.4	18
18, ...	-	26	10	18
19, ...	-	31	14	17
20, ...	-	30	12	16
21, ...	-	27	11	17
22, ...	-	31	12	15
23, ...	-	35	13	13
24, ...	-	35	19	16
25, ...	-	33	17	16
26, ...	-	35	15	14
27, ...	-	44	15	17
28, ...	48	48	16	18
29, ...	42	42	20	19
30, ...	35	35	20	25
31, ...	-	31	18	-

Daily Discharge, in Second-feet, of Otter River near Gardner, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	
1.	27	9.7	48	20	15	74	100	48	50	35	17	38	
2.	27	10	52	17	13	76	100	48	47	32	18	38	
3.	23	10	48	13	9.4	70	98	54	41	30	30	39	
4.	16	9.7	37	11	9.2	60	94	50	43	31	37	35	
5.	11	10	44	7.6	9	62	90	56	45	25	37	25	
6.	9.4	13	46	24	15	60	110	62	45	19	38	24	
7.	8.4	12	44	48	15	62	125	64	47	16	31	31	
8.	8.6	11	37	54	18	62	120	60	53	15	26	30	
9.	8.6	10	30	58	16	68	110	52	49	13	32	35	
10.	7.3	10	30	56	15	68	92	50	46	14	38	25	
11.	6.2	10	28	52	13	72	84	49	46	16	38	21	
12.	5.8	9.4	24	44	10	64	62	44	64	28	38	24	
13.	5.5	13	22	37	6.2	70	60	44	72	35	28	24	
14.	5	16	12	44	13	64	50	41	66	37	20	23	
15.	4.9	15	12	40	12	60	40	42	56	32	20	19	
16.	4.7	13	13	37	14	64	46	36	48	32	19	17	
17.	4	11	12	33	16	64	40	32	46	30	28	18	
18.	4	11	10	33	16	74	54	34	76	29	49	11	
19.	4	11	10	31	14	76	56	37	64	34	49	7.9	
20.	12	12	9	25	16	76	44	35	52	31	38	8.2	
21.	13	9.8	7.9	24	19	66	74	33	47	27	27	8.4	
22.	14	8.2	10	22	16	74	62	35	44	25	23	10	
23.	14	8.1	19	18	16	76	58	39	37	22	24	7.9	
24.	10	35	37	15	24	100	56	50	37	21	31	6.8	
25.	8.7	48	50	16	27	155	54	50	36	22	28	8.9	
26.	10	52	50	14	31	155	48	50	39	20	20	6.3	
27.	9.8	42	46	12	96	180	46	43	36	19	16	5.1	
28.	9.4	44	40	11	84	185	54	40	33	21	13	5.2	
29.	9.7	40	38	10	-	170	50	52	32	17	17	5.2	
30.	11	46	25	15	-	140	46	54	38	17	29	5	
31.	10	-	24	15	-	110	-	53	-	15	28	-	

NOTE. — Stage-discharge relation affected by ice December 12 to 23, December 31 to January 6, and January 12 to February 26; by shifting control and vegetation in the bed of the stream October 1 to November 7, March 25 to April 16, and May 1 to September 30. Daily discharge determined from study of stage-height graph, discharge measurements and weather records.

*Monthly Discharge of Otter River near Gardner, Mass., for the Two-year
Period ending Sept. 30, 1917.*

[Drainage area, 20.0 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1916.					
June 28 to 30, ...	48	35.0	41.7	2.080	.23
July, ...	48	23.0	33.4	1.670	1.92
August, ...	31	9.4	18.0	.900	1.04
September, ...	25	10.0	15.8	.790	.88
1916-17.					
October, ...	27	4.0	10.4	.520	.60
November, ...	52	8.1	18.6	.930	1.04
December, ...	52	7.9	29.6	1.480	1.71
January, ...	58	7.6	27.8	1.390	1.60
February, ...	96	6.2	20.5	1.020	1.06
March, ...	185	60.0	87.2	4.360	5.03
April, ...	125	40.0	70.8	3.540	3.95
May, ...	64	32.0	46.4	2.320	2.65
June, ...	76	32.0	47.9	2.400	2.65
July, ...	37	13.0	24.6	1.230	1.43
August, ...	49	13.0	28.9	1.440	1.66
September, ...	39	5.0	18.6	.930	1.04
The year, ...	185	4.0	36.0	1.800	24.47

East Branch of Tully River near Athol, Mass.

Location. — At highway bridge one-half mile below the mouth of Lawrence Brook and $3\frac{1}{2}$ miles north of Athol.

Drainage Area. — Square miles, 50.2.

Records available. — June 13, 1916, to Sept. 30, 1917.

Gage. — Vertical staff on down-stream side of right abutment; read by W. A. Thompson.

Discharge Measurements. — Made from highway bridge or by wading.

Channel and Control. — Two channels under bridge, one channel above; about 200 feet below the gage the channel is divided by an island, and the control sections are formed by rocks and boulders in the two channels, probably permanent.

Extremes of Discharge. — Maximum stage recorded during the period June 13 to Sept. 30, 1916, 2.94 feet at 7 P.M. July 28 (approximate discharge by extension of rating curve, 300 second-feet); minimum stage recorded during period, 0.46 foot at 6.30 A.M. September 15 (approximate discharge by extension of rating curve, 10 second-feet).

Maximum stage recorded during the year ending Sept. 30, 1917, 3.76 feet at 1 P.M. March 28 (discharge, 780 second-feet); minimum stage recorded during year, 0.34 foot at 6 P.M. August 8 and 7 A.M. August 9 (discharge, 6.0 second-feet).

Diversions. — About one-half mile below the station water is diverted through a canal into Packard Pond. A discharge measurement July 1, 1916, showed a flow of 10.7 second-feet diverted through the canal.

Regulation. — Flow not seriously affected by regulation.

Accuracy. — Stage-discharge relation permanent. Rating curve well defined between 35 and 200 second-feet. Gage read to hundredths twice daily. Daily discharge ascertained by applying mean daily gage heights to rating table. Results good.

Discharge Measurements of East Branch of Tully River near Athol, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
1916.			
June 13, ...	Hardin Thweatt, ...	2.10	151.0
July 1, ...	Hardin Thweatt, ...	1.32	51.0
Aug. 9, ...	H. W. Fear, ...	1.37	52.0
Aug. 25, ...	H. W. Fear, ...	1.54	74.0
Sept. 20, ...	Hardin Thweatt, ...	1.86	121.0
Nov. 8, ...	Hardin Thweatt, ...	1.22	44.0
Dec. 20, ...	Hardin Thweatt, ...	1.28	46.3
1917.			
Jan. 19, ...	Hardin Thweatt, ...	1.84	118.0
Apr. 5, ...	Hardin Thweatt, ...	2.54	279.0
June 14, ...	C. H. Pierce, ...	2.38	226.0
Aug. 2, ...	M. R. Stackpole, ...	.48	9.2

*Daily Discharge, in Second-feet, of East Branch of Tully River near Athol,
Mass., for the Year ending Sept. 30, 1916.*

DAY.	June.	July.	Aug.	Sept.
1, ...	-	54	105	26
2, ...	-	41	79	20
3, ...	-	57	59	16
4, ...	-	80	47	15
5, ...	-	92	37	14
6, ...	-	85	31	14
7, ...	-	69	23	16
8, ...	-	55	24	16
9, ...	-	49	50	18
10, ...	-	54	60	14
11, ...	-	49	47	12
12, ...	-	43	41	12
13, ...	151	35	38	11
14, ...	135	47	41	11
15, ...	117	43	36	15
16, ...	100	28	26	226
17, ...	122	29	21	231
18, ...	193	26	16	177
19, ...	200	20	14	140
20, ...	205	18	14	112
21, ...	188	17	14	89
22, ...	159	18	13	70
23, ...	134	44	13	76
24, ...	110	51	64	157
25, ...	96	44	78	141
26, ...	117	49	57	110
27, ...	124	156	38	76
28, ...	103	289	42	69
29, ...	84	222	52	61
30, ...	74	162	44	113
31, ...	-	129	34	-

Daily Discharge, in Second-feet, of East Branch of Tully River near Athol, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	137	31	200	43	46	141	330	100	106	60	11	312
2.	110	39	185	42	46	141	355	143	92	51	10	237
3.	88	40	141	43	46	123	326	161	80	45	9.5	190
4.	71	37	113	45	43	104	296	147	80	38	8.8	149
5.	62	41	103	46	43	90	273	128	68	35	8.2	121
6.	54	49	100	80	42	80	260	165	72	29	7.2	89
7.	49	49	90	117	40	67	312	166	90	25	6.8	77
8.	40	45	80	123	37	66	316	148	128	20	6.2	66
9.	38	42	72	120	36	76	273	130	161	21	89	69
10.	33	41	74	110	34	78	259	126	137	18	127	64
11.	29	36	77	101	34	76	196	112	123	16	74	45
12.	23	32	71	101	35	78	179	104	210	39	55	39
13.	23	30	73	66	34	86	166	100	232	61	55	34
14.	30	40	71	93	31	85	153	99	229	40	40	30
15.	30	57	63	137	29	80	146	85	193	34	31	27
16.	30	53	58	166	29	76	136	71	170	33	59	24
17.	30	43	56	157	23	85	132	66	157	24	100	22
18.	23	42	53	134	20	113	127	60	188	36	223	20
19.	27	36	51	113	25	120	125	55	170	41	223	19
20.	68	37	49	88	24	96	126	48	134	43	161	18
21.	64	32	47	71	24	90	170	47	110	38	115	17
22.	78	29	64	67	24	93	176	45	89	23	94	17
23.	66	31	84	60	23	107	165	67	80	26	74	16
24.	56	112	103	56	25	202	155	107	73	20	67	14
25.	49	156	104	53	29	344	143	104	88	38	63	14
26.	44	109	90	51	31	381	127	88	78	34	51	14
27.	42	89	77	51	93	445	127	66	66	25	36	12
28.	35	78	70	46	123	775	128	67	58	19	36	12
29.	32	71	65	46	-	675	121	99	51	16	50	14
30.	31	90	67	45	-	510	117	145	69	14	377	14
31.	30	-	49	45	-	429	-	130	-	12	413	-

NOTE. — Stage-discharge relation affected by ice February 9 to 26; discharge determined from study of gage-height graph, observer's notes and weather records.

Monthly Discharge of East Branch of Tully River near Athol, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 50.2 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1916.					
June 13 to 30, ...	205	74.0	134.0	2.670	1.79
July, ...	289	17.0	69.5	1.380	1.59
August, ...	105	13.0	40.6	.809	.91
September, ...	231	11.0	69.3	1.380	1.54
1916-17.					
October, ...	137	27.0	50.0	.996	1.15
November, ...	155	29.0	53.9	1.070	1.19
December, ...	200	47.0	83.4	1.660	1.91
January, ...	165	42.0	81.1	1.620	1.87
February, ...	123	23.0	38.6	.769	.90
March, ...	775	65.0	191.0	3.500	4.35
April, ...	355	117.0	196.0	3.900	4.35
May, ...	165	45.0	103.0	2.050	2.36
June, ...	282	51.0	121.0	2.410	2.69
July, ...	60	12.0	31.2	.622	.72
August, ...	413	6.2	84.8	1.690	1.95
September, ...	312	12.0	59.2	1.180	1.32
The year, ...	775	6.2	91.3	1.820	24.69

Moss Brook at Wendell Depot, Mass.

Location. — About one-fourth mile above confluence with Millers River and one-fourth mile from Wendell Depot.

Drainage Area. — Square miles, 12.2.

Records available. — June 7, 1916, to Sept. 30, 1917. From June 4 to Oct. 16, 1909, records were obtained at a station near the mouth of the stream, and from April 25 to Aug. 27, 1910, at a weir a short distance below the present location.

Gage. — Sloping staff on left bank; read by C. M. Porter.

Discharge Measurements. — Made by wading.

Channel and Control. — Channel composed principally of ledge rock and boulders. Control permanent.

Extremes of Discharge. — Maximum stage recorded during the

period June 7 to Sept. 30, 1916, 2.16 feet at 8 A.M. June 18 (approximate discharge by extension of rating curve, 46 second-feet); minimum stage recorded during period, 0.89 foot at 6.15 P.M. September 14, and 7.15 A.M. September 15 (approximate discharge by extension of rating curve, 1.0 second-foot).

Maximum stage recorded during the year ending Sept. 30, 1917, 3.52 feet at 12.45 P.M. March 28 (discharge, 187 second-feet); minimum stage recorded during year, 0.86 foot at 7.30 A.M. August 29 (discharge, 0.6 second-foot).

Regulation. — Flow not affected by regulation.

Accuracy. — Stage-discharge relation permanent. Rating curve well defined between 2 and 20 second-feet. Gage read to hundredths twice daily. Daily discharge ascertained by applying mean daily gage heights to rating table. Results good.

Discharge Measurements of Moss Brook at Wendell Depot, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
1916.			
June 8, ...	Hardin Thweatt, ...	1.59	16.0
June 8, ...	Hardin Thweatt, ...	1.58	16.1
July 1, ...	Hardin Thweatt, ...	1.39	9.4
Aug. 10, ...	H. W. Fear, ...	1.26	5.8
Aug. 10, ...	Hardin Thweatt, ...	1.26	6.2
Aug. 26, ...	H. W. Fear, ...	1.19	4.7
Nov. 9, ...	Hardin Thweatt, ...	1.33	7.4
Dec. 8, ...	A. H. Davison, ...	1.52	14.7
Dec. 8, ...	A. H. Davison, ...	1.51	12.8
Dec. 20, ...	Hardin Thweatt, ...	1.43 ¹	8.8
1917.			
Jan. 19, ...	H. H. Khachadorian, ...	1.75	23.8
Jan. 19, ...	Hardin Thweatt, ...	1.75	20.5
Feb. 3, ...	H. H. Khachadorian, ...	1.43	10.8
April 5, ...	Hardin Thweatt, ...	2.16	52.0
April 5, ...	Hardin Thweatt, ...	2.16	52.0
June 2, ...	Hardin Thweatt, ...	1.75	27.2
Aug. 3, ...	Hardin Thweatt, ...	1.75	25.8

¹ Stage-discharge relation affected by ice.

*Daily Discharge, in Second-feet, of Moss Brook at Wendell Depot, Mass.,
for the Year ending Sept. 30, 1916.*

Day.	June.	July.	Aug.	Sept.
1, ...	-	9.7	8.6	2.5
2, ...	-	8.1	7	2.2
3, ...	-	16	6.1	1.9
4, ...	-	13	5.2	1.6
5, ...	-	12	4.8	1.5
6, ...	-	10	4.6	1.7
7, ...	20	8.1	4.5	2
8, ...	16	7.8	6.1	1.8
9, ...	17	11	7	1.4
10, ...	22	12	5.7	1.2
11, ...	28	8.6	4.6	1.2
12, ...	28	8.4	4.8	1
13, ...	22	8.1	7	1
14, ...	18	10	5.2	1
15, ...	15	8.1	3.5	6.6
16, ...	15	6.6	3	26
17, ...	24	6.6	2.7	21
18, ...	44	6.6	2.2	11
19, ...	37	5.2	2	10
20, ...	40	4.3	2.1	7.5
21, ...	30	5.2	2	6.1
22, ...	24	7.5	1.8	4.3
23, ...	20	17	1.7	10
24, ...	15	12	9.2	17
25, ...	20	8.1	5.2	11
26, ...	27	15	4.2	7.3
27, ...	21	38	3.8	5.9
28, ...	16	24	5.9	4.6
29, ...	13	17	5.7	4.6
30, ...	11	12	4	19
31, ...	-	10	3	-

Daily Discharge, in Second-feet, of Moss Brook at Wendell Depot, Mass., for the Year ending Sept. 30, 1917.

Day.	1918.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.				9	12	41	53	21	25	16		17
2.			43	9	10	28	74	32	22	13	1.3	12
3.		6.3	22	9	10	22	60	29	22	10	1.6	9
4.		7	19	9	10	18	57	25	19	9.2	2.3	8
5.		6.3	17	9	10	17	50	33	17	8.1	1.4	5.5
6.		10	17	10	10	17	53	48	23	7	1.1	3.8
7.		12	17	21	10	17	53	39	31	7	1	3.4
8.		9.4	15	20	10	16	53	39	31	6.1	1	3.1
9.		8.1	13	30	10	18	43	32	41	6.1	1.8	2.5
10.		5.2	15	23	9	18	40	26	35	5.7	24	2.3
11.		7.5	18	20	9	19	34	24	28	5.7	7	1.7
12.		4.1	14	18	9	19	34	24	28	16	3.4	1.5
13.		6.1	15	17	9	20	31	21	47	12	2.1	1.5
14.		12	17	13	9	21	31	21	61	9.2	1.7	1.4
15.		4.6	17	19	9	21	31	21	61	9.7	1.4	1.3
16.		3.8	16	30	8	20	38	19	52	7.5	2.4	1.3
17.		9.4	13	44	8	19	36	17	41	6.1	5	1.2
18.		8.1	12	33	8	22	24	16	50	11	8.3	1.2
19.		3.4	10	24	8	31	24	15	41	12	2.3	1.1
20.		3.4	9	22	8	32	24	15	30	12	1.5	1.1
21.		20	9	19	8	30	28	14	24	9.2	1.3	1.5
22.		15	8	16	8	29	37	13	21	7.3	1.3	1.3
23.		7.5	26	15	8	25	34	15	17	6.3	1.3	1.1
24.		7.3	19	13	8	25	39	29	15	5	1.7	1.1
25.		8.6	19	13	8	25	35	36	19	4	1.3	1.1
26.		31	25	13	8	25	36	26	20	3.8	1	1.1
27.		27	26	13	10	125	22	21	18	2.8	1	1.1
28.		6.8	17	12	19	107	20	20	16	2.5	7	1.1
29.		5.9	14	10	65	108	23	20	13	2	9.7	2.1
30.		5.2	13	11	46	155	23	20	12	2	43	1.5
31.		5.2	11	13	-	115	24	46	21	2	28	1.4
		-	9	12	-	73	-	32	-	1.5		-

NOTE. — Stage-discharge relation affected by ice December 14 to January 21, and February 8 to 13; discharge for these periods determined from study of gage-height graph, discharge measurements and weather records.

Monthly Discharge of Moss Brook at Wendell Depot, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 12.2 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1916.					
June 7 to 30, ...	44.0	11.0	23.00	1.890	1.69
July, ...	38.0	4.3	11.20	.918	1.06
August, ...	9.2	1.7	4.62	.379	.44
September, ...	36.0	1.0	6.83	.560	.62
1916-17.					
October, ...	20.0	3.4	6.90	.566	.65
November, ...	33.0	6.1	11.60	.951	1.06
December, ...	43.0	8.0	16.90	1.380	1.59
January, ...	44.0	9.0	17.40	1.430	1.65
February, ...	65.0	8.0	12.80	1.050	1.29
March, ...	185.0	16.0	44.60	3.660	4.22
April, ...	74.0	20.0	26.70	2.010	2.34
May, ...	48.0	13.0	26.00	2.130	2.46
June, ...	61.0	12.0	29.60	2.430	2.71
July, ...	16.0	1.5	7.23	.593	.68
August, ...	43.0	.6	5.02	.411	.47
September, ...	17.0	1.0	2.95	.242	.27
The year, ...	185.0	.6	18.20	1.490	20.21

Deerfield River at Charlemont, Mass.

Location. — One mile below the village of Charlemont.

Drainage Area. — Square miles, 362.

Records available. — June 19, 1913, to Sept. 30, 1917.

Gages. — Friez water-stage recorder on left bank, referenced to gage datum by a hook gage inside the well; an outside sloping staff gage is used for auxiliary readings.

Discharge Measurements. — Made from cable or by wading.

Channel and Control. — Channel covered with coarse gravel and boulders; fairly uniform section; control practically permanent.

Extremes of Discharge. — Maximum stage during year ending Sept. 30, 1916, from water-stage recorder, 8.1 feet at 3 P.M. December 26 (discharge, 11,500 second-feet); minimum stage during year from water-stage recorder, 1.58 feet at 5 P.M. September 4 (discharge, 68 second-feet).

Maximum stage during year ending Sept. 30, 1917, from water-stage recorder, 7.53 feet at 10.30 P.M. April 21 (discharge, 9,760 second-feet); minimum stage during year from water-stage recorder, 1.41 feet at 10 A.M. August 7 (discharge, 34 second-feet).

Maximum stage, 1913-17, 15.7 feet on July 8, 1915 (approximate discharge computed from extension of rating curve, 45,000 second-feet); minimum stage recorded, 1.35 feet on Sept. 21 and Nov. 3, 1914 (discharge, 23 second-feet).

Ice. — River usually frozen over during the greater part of the winter; ice jams occasionally form below the gage, causing several feet of backwater.

Regulation. — Flow during low and medium stages largely regulated by a storage reservoir at Somerset, Vt. Several power plants above the station cause diurnal fluctuation.

Accuracy. — Stage-discharge relation practically permanent except during ice periods. Rating curve well defined. The operation of the water-stage recorder was satisfactory except for short periods, as shown in the footnotes to the daily discharge tables. Daily discharge ascertained as follows: October 1 to Dec. 10, 1915, by applying rating table to mean gage height of each two-hour period; Dec. 11, 1915, to June 29, 1916, by applying rating table to mean gage height as determined by averaging gage heights for 12 two-hour periods each day, except when stage-discharge relation was affected by ice (see footnote to daily discharge table); July 3, 1916, to Sept. 30, 1917, by discharge integrator. Results excellent.

*Discharge Measurements of Deerfield River at Charlemont, Mass., during the
Two-year Period ending Sept. 30, 1917.*

DATE.	Made by —	Gage Height (Feet).	Dis- charge (Second- feet).
Oct. 1, ... 1915.	Hardin Thweatt, ...	2.62	559
Jan. 23, ... 1916.	R. S. Barnes, ...	5.84 ¹	3,790
Jan. 31, ...	R. S. Barnes, ...	3.55	1,450
Apr. 4, ...	Hardin Thweatt, ...	4.42	2,680
Apr. 5, ...	Hardin Thweatt, ...	3.87	1,950
Apr. 28, ...	R. S. Barnes, ...	4.58	2,570
Apr. 29, ...	R. S. Barnes, ...	4.38	2,480
June 12, ...	Hardin Thweatt, ...	2.98	840
Jan. 2, ... 1917.	A. H. Davison, ...	6.19 ¹	819
Jan. 22, ...	H. H. Khachadorian, ...	5.09 ¹	530
Jan. 29, ...	Hardin Thweatt, ...	5.30 ¹	625
Feb. 24, ...	H. H. Khachadorian, ...	4.94 ¹	596
Apr. 7, ...	Hardin Thweatt, ...	3.85	1,880

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Deerfield River at Charlemont, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.			1916.									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	
1.	547	719	760	730	3,960	723	5,440	3,040	460	370	570	415	
2.	507	718	648	678	2,560	715	6,780	2,960	394	358	578	350	
3.	485	658	514	635	1,470	678	3,480	2,400	570	457	669	315	
4.	591	649	388	466	1,050	400	2,480	1,180	1,200	463	672	264	
5.	538	669	370	406	862	500	1,970	1,940	708	463	619	265	
6.	1,010	498	332	1,060	915	605	2,110	1,330	942	391	387	385	
7.	679	403	605	960	915	435	2,040	1,270	708	305	340	474	
8.	647	468	663	620	549	455	1,590	1,360	514	316	609	410	
9.	560	588	745	435	663	400	1,330	2,180	753	305	654	357	
10.	398	540	663	535	723	370	1,210	1,540	822	481	452	310	
11.	443	443	570	535	598	370	1,180	978	753	369	330	294	
12.	591	549	505	535	461	400	1,900	822	678	335	265	354	
13.	612	420	577	570	290	370	2,180	626	678	203	366	362	
14.	888	838	830	640	353	370	2,110	888	628	1,650	191	302	
15.	608	635	838	435	570	370	1,970	619	521	755	307	965	
16.	600	1,050	822	400	715	260	2,250	598	531	542	285	1,510	
17.	502	647	862	500	670	256	3,040	4,400	2,490	468	604	648	
18.	489	417	1,900	370	500	310	3,390	3,210	2,320	400	457	263	
19.	660	764	2,760	370	570	370	2,400	1,410	1,470	496	263	240	
20.	634	2,580	1,900	605	260	310	2,790	1,270	1,900	594	316	392	
21.	661	1,360	1,260	605	570	285	2,630	1,060	1,470	435	684	377	
22.	517	1,060	915	1,150	640	310	3,300	846	1,110	730	523	340	
23.	507	812	870	3,210	500	285	4,460	961	888	700	450	370	
24.	304	694	870	1,970	570	280	4,880	1,060	700	555	467	478	
25.	475	587	628	1,360	1,360	285	3,660	806	549	735	300	393	
26.	644	590	4,880	1,770	6,150	400	3,760	670	888	905	296	389	
27.	1,260	554	3,760	3,960	2,710	780	2,870	514	605	1,180	275	363	
28.	766	481	2,110	7,170	2,870	1,360	2,870	607	472	943	466	300	
29.	886	626	1,410	2,570	1,060	2,110	2,550	619	453	018	437	359	
30.	562	962	1,000	1,840	753	2,960	3,040	485	467	361	385	730	
31.	641	-	775	1,530	-	4,880	-	678	-	360	446	-	

NOTE. — Stage-discharge relation affected by ice January 8 to 23, February 15 to 28, and March 2 to 29; discharge estimates for these periods based on gage heights, one discharge measurement, comparisons with power plant records at Shelburne Falls, and weather records. No record by water-stage recorder February 15 to 17, May 18 to 20, June 21 to 23, 30, July 1 and 26; record interpolated graphically.

Daily Discharge, in Second-feet, of Deerfield River at Charlemont, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	380	445	2,200	460	660	2,000	3,100	1,540	990	300	180	590
2.	235	440	1,200	760	470	1,100	4,250	1,720	760	310	205	560
3.	325	510	1,980	620	310	760	2,800	1,700	710	320	250	360
4.	325	395	660	620	175	540	2,650	1,260	810	300	250	340
5.	240	410	840	620	440	440	2,650	1,560	810	240	235	250
6.	150	350	1,300	940	580	430	2,200	1,720	800	235	130	170
7.	265	325	960	880	460	460	1,780	1,540	2,000	190	126	166
8.	255	390	720	780	540	540	1,440	2,000	2,100	220	220	192
9.	90	510	810	330	580	540	1,300	2,260	2,100	190	225	125
10.	435	840	810	330	380	390	1,040	1,680	1,460	195	360	225
11.	425	680	650	185	185	350	920	1,680	1,130	255	305	250
12.	465	300	620	220	195	740	1,020	1,530	2,400	660	250	336
13.	425	450	500	220	370	1,100	910	1,530	2,400	660	250	336
14.	580	640	400	640	400	860	1,080	1,540	1,560	435	274	380
15.	530	560	340	640	480	660	960	1,540	1,100	320	225	400
16.	610	465	380	1,800	540	580	940	1,540	1,400	350	210	310
17.	500	385	330	720	300	520	970	1,200	840	420	460	300
18.	500	380	370	560	560	500	1,660	910	700	375	670	360
19.	500	255	640	420	400	320	2,300	910	580	285	230	360
20.	1,320	225	700	330	430	330	5,740	940	440	390	178	330
21.	960	315	700	190	420	520	6,200	960	350	285	196	330
22.	470	410	720	360	360	620	7,140	830	365	245	150	235
23.	460	860	840	500	430	740	5,220	1,110	300	156	124	102
24.	280	4,900	640	560	480	2,700	3,500	1,100	420	200	200	410
25.	330	1,780	470	640	270	2,600	2,500	990	470	250	440	385
26.	275	750	370	500	480	2,800	2,150	1,020	410	300	370	340
27.	340	660	540	420	2,800	2,460	1,640	800	450	240	160	365
28.	365	560	660	260	2,400	1,940	1,340	870	415	220	166	375
29.	380	520	860	440	2,600	1,340	1,340	2,600	400	220	210	210
30.	375	520	860	660	1,800	1,600	1,740	1,600	590	195	400	290
31.	445	-	260	660	-	1,360	-	1,260	-	200	1,180	-

NOTE. — Stage-discharge relation affected by ice December 14 to March 26; discharge determined from study of stage-height graph, discharge measurements and weather records. Discharge estimated because of no stage-height record October 23 to 27, July 24, 26, and August 3 and 4.

Monthly Discharge of Deerfield River at Charlemont, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 362 square miles.]

MONTH.	OBSERVED DISCHARGE (SECOND-FOOT).			Gain or Loss in Storage at Som- erset, Vt. (Mil- lions of Cubic Feet).	DISCHARGE WITHOUT STORAGE (SECOND- FOOT).		Run-off (Depth in Inches on Drain- age Area).
	Maxi- mum.	Mini- mum.	Mean.		Mean.	Per Square Mile.	
1915-16.							
October, ...	1,250	304	600	-238	492	1.360	1.57
November, ...	2,580	358	715	- 52	695	1.920	2.14
December, ...	4,880	305	1,180	-143	1,130	3.120	3.60
January, ...	7,170	370	1,290	+230	1,380	3.810	4.39
February, ...	6,150	260	1,130	+116	1,180	3.260	3.52
March, ...	4,890	260	728	+ 78	757	2.090	2.41
April, ...	6,780	1,180	2,800	+576	3,080	8.510	9.50
May, ...	4,460	388	1,370	+464	1,540	4.250	4.90
June, ...	2,480	394	890	+183	961	2.650	2.96
July, ...	1,650	305	509	- 47	552	1.520	1.75
August, ...	659	191	427	-648	185	.511	.59
September, ...	1,510	254	439	-335	310	.856	.96
The year, ...	7,170	191	1,010	-	1,010	2.790	38.29
1916-17.							
October, ...	1,820	90	436	-369	298	.823	.95
November, ...	4,900	225	747	+ 29	758	2.090	2.33
December, ...	2,200	260	691	-130	642	1.770	2.04
January, ...	1,800	185	572	-246	480	1.330	1.53
February, ...	3,100	155	590	-448	405	1.120	1.17
March, ...	5,100	320	1,250	+153	1,310	3.620	4.17
April, ...	7,140	900	2,410	+541	2,620	7.240	8.08
May, ...	2,500	800	1,410	+464	1,580	4.360	5.03
June, ...	2,400	300	891	+268	994	2.750	3.07
July, ...	660	156	296	- 71	270	.746	.86
August, ...	1,180	114	299	- 14	294	.812	.94
September, ...	590	102	309	-462	131	.362	.40
The year, ...	7,140	90	821	-	815	2.250	30.57

NOTE. — The increase (+) or decrease (—) of water held in storage at Somerset, Vt., during the month has been computed by engineers of the Geological Survey from data of storage increase or decrease furnished by the company operating the reservoir.

Ware River at Gibbs Crossing, Mass.

Location. — Between the highway and electric railway bridges at Gibbs Crossing, about three-fourths of a mile above the mouth of Beaver Brook and 3 miles below Ware.

Drainage Area. — Square miles, 201.

Records available. — Aug. 20, 1912, to Sept. 30, 1917.

Gages. — Barrett & Lawrence water-stage recorder on the right bank referred to gage datum by a hook gage inside of well; inclined staff gage used for auxiliary readings.

Discharge Measurements. — Made from the electric railway bridge or by wading.

Channel and Control. — Channel rough and subject to a growth of aquatic vegetation during summer months. Control free from weeds, and at ordinary stages well defined at a section near the gage; at high stages the control is probably at the dam at Thorndike, 4 miles below the gage.

Extremes of Discharge. — Maximum stage during year ending Sept. 30, 1916, from water-stage recorder, 5.15 feet at 10 A.M. March 31 (discharge, 2,370 second-feet); minimum stage during year from water-stage recorder, 1.42 feet at 12 noon October 31 and at 5 A.M. November 8 (discharge, 18 second-feet).

Maximum stage during year ending Sept. 30, 1917, from water-stage recorder, 5.25 feet at 6 P.M. February 27 (discharge, 2,430 second-feet); a stage of 6.0 feet was recorded at 10 A.M. February 27, but the water was held back by an ice jam; minimum stage during year from water-stage recorder, 1.45 feet at 4 P.M. September 30 (discharge, 21 second-feet).

Maximum open-water stage recorded, 1912-17, 5.9 feet on March 2, 1914 (discharge, 2,770 second-feet); minimum stage recorded, 1.20 feet on Oct. 26, 1914 (discharge, 5 second-feet).

Ice. — Ice usually forms on the river for short periods during the winter, and affects the stage-discharge relation; the large diurnal variation in flow prevents a rigid ice cover, and the back-water effect is, therefore, variable.

Regulation. — Flow affected by operation of mills at Ware, which at low stages causes a large variation in discharge on days when the mills are in operation, and a low discharge on Sundays and holidays.

Accuracy. — Stage-discharge relation practically permanent except during ice periods. Rating curve well defined. The

operation of water-stage recorder was satisfactory except for short periods, as shown in footnotes to the discharge tables. Daily discharge ascertained as follows: Oct. 1, 1915, to April 28, 1916, by applying rating table to mean daily gage heights; April 29, 1916, to Sept. 30, 1917, by discharge integrator. Results good.

Discharge Measurements of Ware River at Gibbs Crossing, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
1916.			
Jan. 19, ...	Hardin Thweatt, ...	3.39 ¹	406
Jan. 19, ...	Hardin Thweatt, ...	3.10 ¹	223
Mar. 28, ...	Hardin Thweatt, ...	3.62	1,060
1917.			
Jan. 24, ...	H. H. Khachadorian, ...	3.16 ¹	223
Feb. 26, ...	H. H. Khachadorian, ...	3.94 ¹	382
Mar. 4, ...	Hardin Thweatt, ...	2.97	451
Aug. 13, ...	M. R. Stackpole, ...	2.05	116

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Ware River at Gibbs Crossing, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.			1916.										
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.		
1.	72	79	116	468	522	1,040	2,160	810	360	300	500	135		
2.	51	87	120	393	464	790	2,240	700	310	255	420	90		
3.	29	81	109	408	358	668	2,100	690	210	330	360	40		
4.	68	79	81	398	353	557	1,680	725	265	415	300	100		
5.	68	76	37	333	373	487	1,240	720	360	390	210	110		
6.	70	54	123	550	324	487	1,160	620	430	425	275	120		
7.	105	21	95	557	353	460	1,110	555	410	355	255	110		
8.	125	60	97	398	368	432	1,050	575	385	325	300	110		
9.	105	73	99	311	272	378	958	490	350	300	415	75		
10.	130	71	101	324	297	403	967	455	380	375	390	35		
11.	142	69	79	338	268	383	1,020	470	560	360	320	90		
12.	127	74	44	306	256	315	1,070	350	690	305	245	100		
13.	93	54	83	311	204	388	1,090	355	650	240	228	100		
14.	81	24	120	315	236	363	1,120	325	590	245	260	100		
15.	85	58	159	256	236	343	1,200	375	490	165	280	130		
16.	79	140	137	226	220	329	1,120	380	440	100	190	95		
17.	54	130	113	200	200	329	1,090	635	565	140	170	145		
18.	132	116	183	200	220	315	945	1,130	790	135	180	175		
19.	99	123	100	200	220	302	820	990	850	110	115	220		
20.	105	153	923	236	200	343	763	860	835	85	75	150		
21.	103	211	420	306	200	507	718	680	690	95	180	125		
22.	107	228	432	373	200	284	745	600	590	50	140	120		
23.	69	232	368	860	193	280	912	530	510	260	135	80		
24.	28	171	276	690	221	302	1,000	640	420	460	130	45		
25.	107	111	422	522	306	356	1,070	600	360	360	120	145		
26.	91	162	450	536	1,410	378	965	425	540	395	65	130		
27.	109	89	1,220	676	1,520	564	900	265	505	825	100	130		
28.	107	99	1,080	860	1,440	901	840	325	480	1,940	140	130		
29.	83	145	870	763	1,310	1,300	835	360	440	1,120	165	130		
30.	54	137	628	550	-	1,640	845	365	385	755	165	90		
31.	20	-	438	522	-	2,240	-	370	-	605	130	-		

NOTE. — Stage-discharge relation affected by ice January 16 to 20 and February 14 to 22; discharge estimates for these periods based on gauge heights, two discharge measurements and weather records. No record by water-stage recorder April 26 and 27, July 8 to 10 and September 27 and 28; flow estimated by comparison with records in adjacent drainage basins.

Daily Discharge, in Second-feet, of Ware River at Gibbs Crossing, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	100	94	270	165	115	1,040	1,120	435	425	275	90	92
2.	142	100	265	210	120	600	1,060	660	360	290	70	70
3.	130	86	265	195	88	520	960	630	310	290	94	64
4.	134	80	195	200	76	465	890	485	360	178	98	114
5.	116	42	205	240	130	440	800	485	300	225	34	114
6.	114	82	180	260	125	370	760	630	305	250	85	114
7.	64	100	160	330	130	365	890	720	330	134	91	112
8.	30	120	160	370	110	460	920	650	370	120	78	87
9.	80	120	120	350	110	710	920	600	310	200	92	35
10.	90	110	140	300	95	790	790	640	270	190	80	99
11.	85	80	170	300	85	640	690	510	420	205	93	100
12.	90	50	210	300	90	770	610	460	610	200	88	88
13.	90	120	205	350	90	840	590	430	750	200	98	67
14.	60	110	210	450	100	750	530	500	610	145	97	56
15.	50	102	180	680	140	700	475	500	530	184	96	44
16.	100	140	125	500	130	750	490	410	415	170	93	20
17.	84	130	125	435	75	830	470	370	410	172	112	43
18.	98	80	120	340	72	930	640	340	640	150	78	68
19.	110	100	120	250	180	860	355	245	600	145	73	68
20.	120	130	115	220	135	710	430	260	510	138	132	65
21.	90	100	125	180	130	680	500	315	440	96	95	59
22.	120	100	180	170	100	740	420	325	365	72	88	50
23.	125	130	250	190	76	780	510	225	310	130	84	50
24.	115	180	290	130	80	1,120	480	390	245	124	73	75
25.	120	255	220	110	110	1,500	415	340	310	108	68	61
26.	108	180	320	105	320	1,400	390	335	295	120	80	69
27.	100	160	410	100	1,720	1,400	405	240	325	110	71	80
28.	62	180	200	72	2,060	2,160	445	350	270	64	78	75
29.	35	135	320	100	-	2,160	380	530	245	29	114	60
30.	94	145	200	120	-	1,720	415	610	260	110	156	20
31.	90	-	180	90	-	1,260	-	490	-	102	142	-

NOTE. — Stage-discharge relation affected by ice December 17 to 21, December 30 to January 2, January 12, 13, and January 20 to February 28; discharge for these periods determined from study of gage-height graph, discharge measurements, weather records and comparison with similar studies for near-by streams.

Monthly Discharge of Ware River at Gibbs Crossing, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 201 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1915-16.					
October, ...	142	20	87.5	.435	.50
November, ...	232	21	108.0	.537	.60
December, ...	1,230	37	353.0	1.760	2.63
January, ...	860	200	430.0	2.146	2.47
February, ...	1,820	193	452.0	2.250	2.43
March, ...	2,240	256	566.0	2.830	3.25
April, ...	2,240	718	1,120.0	5.570	6.21
May, ...	1,130	325	555.0	2.760	3.13
June, ...	880	210	495.0	2.460	2.74
July, ...	1,640	50	393.0	1.960	2.28
August, ...	500	75	226.0	1.120	1.29
September, ...	220	35	112.0	.557	.62
The year, ...	2,240	10	407.0	2.020	27.58
1916-17.					
October, ...	142	30	94.7	.471	.54
November, ...	255	42	117.0	.582	.65
December, ...	410	115	196.0	.975	1.12
January, ...	680	72	252.0	1.250	1.44
February, ...	2,060	72	242.0	1.200	1.25
March, ...	2,160	365	918.0	4.570	5.27
April, ...	1,120	380	619.0	3.080	3.44
May, ...	720	225	445.0	2.210	2.55
June, ...	750	245	397.0	1.980	2.21
July, ...	200	29	159.0	.791	.91
August, ...	156	30	86.5	.430	.50
September, ...	114	20	70.4	.350	.39
The year, ...	2,160	20	300.0	1.490	20.27

Swift River at West Ware, Mass.

Location. — About 1,000 feet below the old wooden dam opposite the West Ware station of the Boston & Albany Railroad, about 6 miles down-stream from Enfield, and 3 miles below the confluence of East and West branches of Swift River.

Drainage Area. — Square miles, 186.

Records available. — July 15, 1910, to Sept. 30, 1917.

Gages. — Barrett & Lawrence water-stage recorder on left bank, referenced to gage datum by means of a hook gage inside the well; an inclined staff gage is used for auxiliary readings. Prior to Aug. 25, 1912, a chain gage on footbridge 600 feet up-stream from the present station.

Discharge Measurements. — Made from cable or by wading.

Channel and Control. — Gravel and alluvial deposits; some aquatic vegetation in channel during summer. Control practically permanent at ordinary stages; at high stages the control is probably at the dam at Bondsville, 4 miles below the gage.

Extremes of Discharge. — Maximum stage during year ending Sept. 30, 1916, from water-stage recorder, 8.45 feet at 12.30 noon April 3 (discharge, 1,970 second-feet); minimum stage during year from water-stage recorder, 1.64 feet at 1.30 A.M. December 14 (discharge, 47 second-feet).

Maximum stage during year ending Sept. 30, 1917, from water-stage recorder, 7.9 feet some time between March 23 and April 1 (discharge, 1,800 second-feet); minimum stage during year from water-stage recorder, 1.87 feet at 8 A.M. August 8 (discharge, 67 second-feet).

Maximum stage recorded, 1910-17, 9.1 feet on Feb. 26, 1915 (discharge by extension of rating curve, 2,240 second-feet); minimum stage recorded, 1.36 feet on Sept. 22, 1914 (discharge, 22 second-feet).

Ice. — River usually freezes over for short periods during the winter, and the stage-discharge relation is somewhat affected by the ice.

Regulation. — Operation of mills at Enfield 6 miles above the station affects distribution of flow at low and medium stages, but has only a slight effect when the mean daily discharge is over 200 second-feet.

Accuracy. — Stage-discharge relation practically permanent, except for a change during high water April 3, 1916, caused by the washing out of a portion of an old timber dam just above

the station. Débris from this washout affected the operation of the water-stage recorder April 3 to July 20, 1916. Gage heights during this period corrected by the aid of readings by the observer on outside staff gage, and by comparisons with hydrographs of near-by streams. Rating curve well defined below 1,200 second-feet. Daily discharge ascertained by applying rating table to mean daily gage heights determined by inspection of gage-height graph or, for days of considerable fluctuation, by averaging the mean gage heights of four-hour periods. Results from January 1 to July 20, 1916, and from Dec. 12, 1916, to March 25, 1917, are only fair, but are good for the remainder of the two-year period.

Discharge Measurements of Swift River at West Ware, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
1916.			
Jan. 27, ...	Hardin Thweatt, ...	4.10	630
Jan. 27, ...	Hardin Thweatt, ...	4.12	585
Jan. 27, ...	Hardin Thweatt, ...	4.15	604
Mar. 30, ...	Hardin Thweatt, ...	5.11	965
Mar. 30, ...	Hardin Thweatt, ...	5.55	1,070
July 20, ...	Hardin Thweatt, ...	2.48	181
Aug. 12, ...	Hardin Thweatt, ...	2.77	220
Aug. 12, ...	H. W. Fear, ...	2.81	220
1917.			
Jan. 24, ...	H. H. Khachadoorian, ...	3.32 ¹	222
Feb. 27, ...	H. H. Khachadoorian, ...	4.59 ¹	603
Mar. 5, ...	Hardin Thweatt, ...	4.05 ¹	352
Aug. 13, ...	M. R. Stackpole, ...	2.27	123

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Swift River at West Ware, Mass., for the Year ending Sept. 30, 1918.

Day.	1915.			1916.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	89	101	156	665	635	685	1,590	560	365	314	455	164
2.	96	104	152	661	645	640	1,740	645	345	192	322	146
3.	110	101	127	518	490	770	1,770	650	235	214	352	138
4.	106	102	128	444	460	660	1,890	615	268	363	309	121
5.	110	104	121	397	430	635	1,880	476	258	325	182	112
6.	130	100	117	447	390	635	1,200	434	330	440	170	118
7.	127	98	115	429	365	590	1,116	416	380	425	157	121
8.	164	93	120	394	340	545	970	426	380	312	168	115
9.	182	84	117	368	315	470	900	440	333	362	196	109
10.	188	85	109	355	305	460	843	410	330	368	216	107
11.	156	86	109	352	290	440	830	350	338	353	223	110
12.	149	86	98	324	290	396	865	308	455	235	218	97
13.	130	82	94	314	265	420	935	252	600	225	202	97
14.	121	84	87	330	255	410	1,040	232	440	238	184	97
15.	127	110	100	250	250	360	1,120	245	360	202	164	113
16.	146	123	101	256	245	360	1,110	312	345	162	157	230
17.	141	143	112	255	240	335	1,040	440	425	153	148	298
18.	136	166	215	240	235	320	935	690	615	153	135	308
19.	127	168	402	220	230	300	843	882	605	162	123	290
20.	136	194	360	210	210	320	725	830	690	136	105	245
21.	143	225	610	210	215	300	690	665	708	131	118	216
22.	137	277	669	187	220	300	672	645	638	144	97	182
23.	136	232	447	475	230	290	708	470	645	190	109	170
24.	127	210	376	475	230	300	778	440	440	240	144	252
25.	106	194	332	505	290	276	812	410	374	200	178	290
26.	101	156	595	608	350	270	795	280	449	230	184	308
27.	109	145	848	610	1,200	535	725	350	455	345	176	263
28.	96	150	1,000	742	1,100	785	638	312	365	605	165	245
29.	107	143	1,000	830	1,000	900	605	285	312	830	194	228
30.	100	150	812	742	1,000	1,000	675	258	250	812	204	275
31.	96	-	738	672	-	1,200	-	275	-	620	190	-

NOTE. — Stage-discharge relation affected by ice January 7 to 10, 15 to 19, and February 4 to 24; discharge for these periods determined from study of gage-height graph, discharge measurements, weather records and comparison with similar studies for near-by streams. Discharge December 31 to January 3, and February 24 to March 29, estimated by comparisons with near-by streams, because of no gage-height record.

Daily Discharge, in Second-feet, of Swift River at West Ware, Mass., for the Year ending Sept. 30, 1917.

Date.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	300	144	328	180	130	720	1,120	375	500	255	102	275
2.	310	148	358	190	140	600	1,040	425	440	255	98	265
3.	285	146	410	180	130	500	970	455	375	245	104	240
4.	250	140	405	210	120	420	900	440	240	225	89	192
5.	225	142	400	210	120	350	850	455	300	210	82	160
6.	198	158	360	340	150	340	800	530	265	185	99	140
7.	183	172	328	410	140	340	760	540	310	170	83	135
8.	180	186	300	460	130	400	720	560	375	155	83	114
9.	162	184	260	400	130	520	660	500	350	170	82	110
10.	142	176	230	220	110	660	610	455	330	150	126	100
11.	144	166	220	180	100	530	580	410	485	180	93	104
12.	155	154	220	180	100	500	560	405	610	180	110	102
13.	140	148	220	200	100	760	580	390	610	155	102	104
14.	125	154	230	240	100	560	530	370	560	170	108	95
15.	128	174	220	360	110	350	470	340	500	183	106	95
16.	126	188	190	420	110	340	410	310	470	180	106	97
17.	128	196	190	420	110	500	440	295	500	168	146	96
18.	120	192	180	340	120	560	420	275	500	168	146	96
19.	120	176	180	280	140	520	420	275	470	184	196	96
20.	138	158	180	240	140	560	410	255	440	172	154	93
21.	150	140	180	180	140	500	440	250	380	160	150	97
22.	164	142	220	180	150	455	455	250	350	163	150	93
23.	172	136	380	160	150	500	470	290	295	160	128	85
24.	168	182	340	160	160	455	455	270	270	144	114	93
25.	162	250	350	140	180	860	425	355	260	144	108	93
26.	156	320	320	140	180	990	395	325	245	138	110	90
27.	154	310	340	150	160	1,000	385	325	250	134	108	88
28.	144	270	300	120	850	1,120	380	410	240	122	100	92
29.	140	240	190	110	-	1,260	380	410	225	116	99	88
30.	140	230	180	130	-	1,220	375	560	245	120	154	86
31.	130	-	180	130	-	1,160	-	560	-	104	300	-

NOTE. — Stage-discharge relation affected by ice December 12 to March 25; discharge determined from study of stage-height graph, discharge measurements, weather records and comparison with similar studies for near-by streams. Discharge November 25, March, 26 to 31, April 2 to 6, 8 to 19, May 7, July 6 to 15, and September 6 and 7, estimated by hydrograph comparison with near-by streams.

*Monthly Discharge of Swift River at West Ware, Mass., for the Two-year
Period ending Sept. 30, 1917.*

[Drainage area, 186 square miles.]

MONTHS.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1915-16.					
October, ...	188	89	127	.683	.79
November, ...	277	83	136	.731	.82
December, ...	1,100	83	340	1.830	2.11
January, ...	830	210	429	2.310	2.66
February, ...	1,300	210	417	2.240	2.42
March, ...	1,390	275	535	2.880	3.32
April, ...	1,770	575	985	5.300	5.91
May, ...	882	232	442	2.380	2.74
June, ...	708	225	408	2.190	2.44
July, ...	830	131	297	1.600	1.84
August, ...	455	97	185	.995	1.15
September, ...	308	97	185	.995	1.11
The year, ...	1,770	82	373	2.010	27.31
1916-17.					
October, ...	310	120	169	.909	1.05
November, ...	320	136	184	.989	1.10
December, ...	410	180	270	1.450	1.67
January, ...	460	110	234	1.260	1.45
February, ...	830	100	172	.925	.92
March, ...	1,260	340	645	3.470	4.00
April, ...	1,120	375	588	3.160	3.53
May, ...	560	250	398	2.140	2.47
June, ...	610	225	379	2.040	2.28
July, ...	255	104	169	.909	1.05
August, ...	300	82	118	.634	.73
September, ...	275	85	121	.651	.73
The year, ...	1,260	82	288	1.650	20.98

Quaboag River at West Brimfield, Mass.

Location. — At the two-span highway bridge near the West Brimfield station of the Boston & Albany Railroad; one-third of a mile above the mouth of Blodgett Mill Brook.

Drainage Area. — Square miles, 150.

Records available. — Aug. 23, 1909, to Sept. 30, 1917.

Gages. — Stevens continuous water-stage recorder at downstream end of center pier of bridge, referenced to gage datum by means of a hook gage inside of well. Vertical staff is used for auxiliary readings. Prior to Aug. 19, 1912, a vertical staff on up-stream side of right abutment of bridge at same datum as present gage.

Discharge Measurements. — Made from highway bridge or by wading near bridge.

Channel and Control. — Stream bed covered with boulders, gravel and alluvial deposits; control practically permanent.

Extremes of Discharge. — Maximum open-water stage during year ending Sept. 30, 1916, from water-stage recorder, 4.23 feet at 7.45 A.M. April 3 (discharge, 1,210 second-feet); a stage of 5.05 feet was recorded at 12 noon January 19, but the water was held back by an ice jam; minimum stage during year from water-stage recorder, 1.72 feet at 4.30 A.M. September 15 (discharge, 20 second-feet).

Maximum open-water stage during year ending Sept. 30, 1917, from water-stage recorder, 4.02 feet at 8.15 A.M. March 29 and 8.30 A.M. March 30 (discharge, 1,100 second-feet); a stage of 4.85 feet was recorded at 8.15 A.M. March 13, but the water was held back by an ice jam; minimum stage during year from water-stage recorder, 1.57 feet at 12 noon September 30 (discharge, about 13 second-feet).

Maximum stage recorded, 1909–17, 4.9 feet on March 1, 1910 (discharge, 1,660 second-feet); minimum stage recorded, 1.40 feet on Sept. 17 and 18, 1910 (discharge, 2.5 second-feet).

Ice. — Ice usually forms on the river for short periods during the winter and affects the stage-discharge relation; the large diurnal variation in flow prevents a rigid ice cover, and the back-water effect is, therefore, variable.

Regulation. — Flow affected by operation of power plants at West Warren, 3 miles above station, which at low stages causes a large variation in discharge on days when the mills are in operation and a low discharge on Sundays and holidays.

Accuracy. — Stage-discharge relation practically permanent except during ice periods. Rating curve well defined. The operation of the water-stage recorder was satisfactory throughout the year except for short periods, as shown in the footnotes to daily discharge tables. Daily discharge ascertained as follows: Oct. 1, 1915, to March 28, 1916, by applying rating table to mean daily gage heights determined by planimeter; March 29, 1916, to Sept. 30, 1917, by discharge integrator. Results excellent.

Discharge Measurements of Quaboag River at West Brimfield, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
Dec. 17, ... 1915.	Hardin Thweatt, ...	2.93 ¹	175
Jan. 17, ... 1916.	Hardin Thweatt, ...	2.90 ¹	186
Mar. 29, ...	Hardin Thweatt, ...	3.40	660
Aug. 11, ...	H. W. Fear, ...	2.72	256
Dec. 23, ...	Hardin Thweatt, ...	2.37 ¹	106
Jan. 25, ... 1917.	Hardin Thweatt, ...	3.78 ¹	219
Mar. 3, ...	Hardin Thweatt, ...	4.18 ¹	407
May 25, ...	Hardin Thweatt, ...	2.67	263
Aug. 18, ...	M. R. Stackpole, ...	2.54	214

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Quaboag River at West Brimfield, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.			1916.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1,	59	101	103	340	380	774	1,080	510	240	225	455	130
2,	61	96	98	293	360	756	1,100	470	225	215	430	110
3,	56	87	98	270	350	749	1,140	455	200	240	395	114
4,	63	87	96	290	270	709	1,120	475	210	225	370	114
5,	78	98	65	350	350	682	1,050	445	210	220	340	138
6,	94	81	105	417	325	661	1,020	420	235	210	325	120
7,	100	69	87	391	325	640	930	410	225	200	310	114
8,	110	87	83	365	230	575	870	405	225	190	325	122
9,	110	83	67	340	293	463	840	365	245	176	350	93
10,	94	83	73	315	250	444	790	350	270	188	320	104
11,	113	69	73	340	250	423	780	325	310	184	310	132
12,	110	71	60	293	145	407	770	275	355	174	295	104
13,	100	69	73	302	145	390	740	285	300	172	280	97
14,	101	46	90	293	210	340	780	280	300	172	260	93
15,	105	105	110	176	175	315	800	280	350	150	240	110
16,	110	89	125	270	175	293	770	270	335	153	230	184
17,	90	87	176	250	145	293	740	460	390	160	220	172
18,	100	87	210	230	175	270	670	475	420	150	210	178
19,	110	110	401	200	175	250	610	440	445	142	194	178
20,	110	154	234	230	175	250	610	420	475	132	186	168
21,	120	133	250	175	175	250	580	415	455	168	190	164
22,	145	145	210	297	175	270	580	400	440	144	170	160
23,	130	125	210	380	175	250	620	385	415	210	152	144
24,	110	118	222	401	175	260	610	375	385	215	176	146
25,	136	110	238	370	210	290	580	345	390	210	160	150
26,	125	130	391	391	797	560	560	325	395	245	146	128
27,	123	98	306	417	688	450	530	300	355	465	144	120
28,	113	98	455	407	783	450	550	290	325	620	162	120
29,	110	125	325	380	774	660	640	280	390	530	152	120
30,	91	110	325	385	-	850	630	250	360	510	156	160
31,	77	-	293	335	-	1,040	-	235	-	490	140	-

NOTE. — Stage-discharge relation affected by ice December 14 to 18, 21 to 23, December 31 to January 4, January 7 to 12, 16 to 21, February 9 to 25 and March 15 to 24; discharge estimates for these periods based on gage heights, two discharge measurements, observer's notes and weather records. No record by water-stage recorder October 5, 7 to 9, 12, 13, 16 to 24, and December 10 to 13; flow estimated by comparison with records on nearby streams.

Daily Discharge, in Second-feet, of Quaboag River at West Brimfield, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	134	91	168	140	135	680	960	265	300	180	85	130
2.	142	96	160	140	125	540	930	290	285	162	91	128
3.	120	85	152	145	120	420	850	275	275	143	96	124
4.	120	77	158	150	120	380	790	275	260	128	74	133
5.	116	90	148	230	145	370	730	325	340	126	77	130
6.	112	130	142	320	160	320	720	355	335	68	91	120
7.	90	106	118	320	160	320	710	355	345	73	84	112
8.	92	104	130	250	155	520	690	350	240	70	80	93
9.	120	100	132	140	150	640	670	350	230	92	96	96
10.	91	94	134	160	130	580	580	330	210	80	84	114
11.	92	79	136	155	125	520	560	290	250	83	75	84
12.	96	89	148	150	115	620	570	300	340	102	91	83
13.	96	114	132	280	110	780	540	310	310	102	83	80
14.	71	100	124	360	120	460	490	290	295	92	88	86
15.	96	96	120	340	130	435	400	265	280	114	90	64
16.	112	95	120	320	130	435	415	260	285	134	81	55
17.	87	96	115	280	130	460	395	245	310	118	123	91
18.	85	85	110	220	120	500	360	235	320	118	120	70
19.	94	80	105	210	145	500	390	230	320	114	120	69
20.	140	114	100	195	145	440	350	200	305	112	102	70
21.	136	90	96	175	145	450	345	183	260	106	87	63
22.	126	90	100	160	130	465	345	186	265	114	85	55
23.	124	100	105	165	125	485	310	225	235	120	91	54
24.	116	160	150	150	120	650	298	225	230	102	96	80
25.	114	123	170	145	120	720	270	230	210	92	96	70
26.	110	114	220	150	250	740	260	215	200	100	67	63
27.	106	143	200	150	840	790	270	220	235	93	96	62
28.	80	134	180	145	760	970	260	240	180	82	77	62
29.	77	108	170	150	760	1,000	265	340	134	74	85	43
30.	110	140	155	130	-	980	265	320	180	104	126	30
31.	90	-	155	130	-	980	-	310	-	88	174	-

NOTE. — Stage-discharge relation affected by ice December 14 to March 13; discharge determined from study of gage-height graph, discharge measurements, weather records and comparison with similar studies for near-by streams.

*Monthly Discharge of Quaboag River at West Brimfield, Mass., for the Two-
year Period ending Sept. 30, 1917.*

[Drainage area, 150 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches at Drainage Area.
1915-16.					
October, ...	136	56	101.0	.673	.78
November, ...	154	46	99.0	.660	.74
December, ...	455	60	188.0	1.250	1.44
January, ...	417	176	320.0	2.130	2.46
February, ...	797	145	305.0	2.030	2.19
March, ...	1,040	250	480.0	3.200	3.69
April, ...	1,140	530	764.0	5.090	5.64
May, ...	510	250	369.0	2.460	2.84
June, ...	475	200	326.0	2.170	2.42
July, ...	620	132	241.0	1.610	1.86
August, ...	455	140	281.0	1.670	1.92
September, ...	184	93	133.0	.887	.99
The year, ...	1,140	46	298.0	1.990	27.01
1916-17.					
October, ...	142	71	106.0	.707	.82
November, ...	160	77	104.0	.693	.77
December, ...	260	95	141.0	.940	1.06
January, ...	360	130	199.0	1.330	1.53
February, ...	840	110	184.0	1.230	1.28
March, ...	1,000	320	580.0	3.870	4.46
April, ...	960	260	501.0	3.340	3.73
May, ...	355	182	273.0	1.820	2.10
June, ...	340	124	255.0	1.700	1.90
July, ...	180	72	107.0	.713	.82
August, ...	174	66	91.4	.609	.70
September, ...	138	80	83.6	.557	.62
The year, ...	1,000	30	219.0	1.480	19.51

Westfield River at Knightville, Mass.

Location. — At single-span steel highway bridge known locally as Pitcher Bridge, in Knightville, 1 mile north of outlet of Norwich Lake, and about 3 miles above confluence with Middle Branch of Westfield River.

Drainage Area. — Square miles, 162.

Records available. — Aug. 26, 1909, to Sept. 30, 1917.

Gage. — Chain attached to down-stream side of highway bridge; read by J. A. Burr.

Discharge Measurements. — Made from highway bridge or by wading.

Channel and Control. — Channel rough, covered with boulders and ledge rock; control practically permanent.

Extremes of Discharge. — Maximum stage recorded during year ending Sept. 30, 1916, 6.24 feet at 8 A.M. February 26 (approximate discharge by extension of rating curve, 2,910 second-feet); minimum stage recorded during year, 1.0 foot at 5 P.M. September 13, and 7 A.M. September 14 (discharge, 28 second-feet).

Maximum stage recorded during year ending Sept. 30, 1917 5.8 feet at 7 A.M. March 28 (discharge, 3,030 second-feet); minimum stage recorded during year, 0.81 foot several times in September (discharge, 16 second-feet).

Maximum open-water stage recorded, 1909-17, 8.9 feet on March 27, 1913 (approximate discharge, 5,100 second-feet); a gage height of 9.4 feet was recorded at 9.15 A.M. Jan. 22, 1910, but channel was probably obstructed by ice at that time; minimum stage recorded, 0.60 foot on Aug. 10, 1913 (discharge, 4 second-feet).

Ice. — Ice usually forms in the river early in the winter, affecting the stage-discharge relation, but is generally carried out by the first sudden rise in stage, leaving the channel clear. These conditions may be repeated several times during the winter.

Regulation. — Flow not seriously affected by regulation.

Accuracy. — The stage-discharge relation has probably remained permanent, except during ice periods, although individual discharge measurements have at times appeared erratic. The rough and irregular channel causes difficulty in securing accurate discharge measurements. Rating curve fairly well defined below 2,000 second-feet. Gage read to hundredths twice daily, except during the winter, when it is read once daily. Daily discharge ascertained by applying rating table to mean daily gage heights. Results good.

*Discharge Measurements of Westfield River at Knightville, Mass., during
the Two-year Period ending Sept. 30, 1917.*

DATE.	Made by —	Gage Height (Feet).	Dis- charge (Second- feet).
Dec. 23, ... 1915.	Hardin Thweatt, ...	2.33 ¹	300 0
Jan. 25, ... 1916.	Hardin Thweatt, ...	2.83	497 0
Mar. 26, ...	Hardin Thweatt, ...	2.38	316 0
Dec. 5, ...	A. H. Davison, ...	2.17	238 0
Dec. 5, ...	A. H. Davison, ...	2.18	278 0
Jan. 5, ... 1917.	A. H. Davison, ...	2.44 ¹	126 0
Feb. 5, ...	A. H. Davison, ...	2.40 ¹	99 0
Mar. 2, ...	A. H. Davison, ...	4.12 ¹	326 0
Mar. 28, ...	Hardin Thweatt, ...	5.45	2,730 0
May 24, ...	Hardin Thweatt, ...	2.68	470 0
June 1, ...	Hardin Thweatt, ...	2.57	298 0
June 1, ...	Hardin Thweatt, ...	2.57	400 0
Aug. 7, ...	M. R. Stackpole, ...	1.14	35.3
Aug. 7, ...	M. R. Stackpole, ...	1.12	34.0
Aug. 17, ...	M. R. Stackpole, ...	1.02	28.1

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Westfield River at Knightville, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.			1916.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	88	116	201	420	1,440	580	1,900	610	176	112	118	53
2.	94	112	170	395	920	470	2,060	523	156	101	99	48
3.	204	104	173	395	670	445	1,310	470	158	238	87	46
4.	120	112	120	330	495	395	1,310	495	550	222	79	44
5.	121	112	120	395	495	372	1,180	420	372	153	90	46
6.	222	120	120	395	495	330	1,240	373	310	143	88	40
7.	156	112	120	650	470	330	1,180	350	255	123	76	60
8.	372	104	170	610	310	310	985	495	222	103	70	50
9.	238	108	170	372	350	310	700	385	330	272	109	38
10.	179	99	166	238	350	310	700	385	372	207	123	30
11.	139	97	141	238	310	272	855	301	395	171	110	32
12.	112	90	120	222	310	265	1,390	310	420	134	104	35
13.	101	87	120	255	291	272	1,180	255	255	148	94	26
14.	158	153	120	238	222	238	1,440	222	204	163	67	153
15.	207	255	120	222	192	222	1,310	255	204	116	61	855
16.	156	179	120	207	238	238	1,310	204	670	104	59	196
17.	120	131	350	192	222	222	1,050	985	580	151	58	134
18.	121	238	1,180	153	222	238	1,050	580	395	125	50	121
19.	131	730	1,790	192	222	265	985	420	350	94	38	94
20.	174	445	495	222	207	265	920	350	330	148	42	79
21.	143	255	372	350	207	272	1,060	291	291	143	36	71
22.	116	207	330	1,240	238	272	1,310	445	238	148	88	82
23.	97	183	272	1,790	238	222	1,390	372	196	134	310	207
24.	97	166	310	580	470	238	1,060	330	238	121	123	121
25.	94	153	2,280	585	2,590	330	855	372	255	174	82	90
26.	272	158	1,710	1,710	408	330	730	268	238	700	64	79
27.	207	188	1,180	1,710	408	330	730	268	238	306	103	71
28.	168	166	920	2,280	1,570	700	855	207	187	306	103	71
29.	139	272	495	1,310	670	1,380	920	201	158	255	118	60
30.	116	-	420	790	-	1,920	730	222	134	158	80	522
31.	-	-	-	-	-	-	-	222	-	134	59	-

NOTE. — Stage-discharge relation affected by ice December 5 to 18, 22 to 24, January 10 to 22 and February 13 to 24; estimates during these periods based on gage heights, two discharge measurements, observer's notes and weather records.

Daily Discharge, in Second-feet, of Westfield River at Knightville, Mass., for the Year ending Sept. 30, 1917.

1916.			1917.									
Day.				Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
	Oct.	Nov.	Dec.	120	140	640	1,520	412	412	200	50	55
1.	.	94	730	195	110	420	1,690	505	390	172	47	52
2.	.	129	335	165	90	310	1,280	512	345	167	65	47
3.	.	104	272	140	88	240	1,120	435	305	138	57	45
4.	.	97	238	110	82	180	1,120	460	265	117	50	37
5.	.	88	255	110	100	165	980	980	655	103	44	30
6.	.	130	255	680	90	140	1,120	780	910	92	43	27
7.	.	174	207	520	82	240	1,120	715	1,120	81	37	30
8.	.	185	186	270	74	400	845	655	568	81	41	37
9.	.	60	143	250	74	270	655	540	460	89	47	33
10.	.	166	201	240	68	210	395	460	1,050	107	43	30
11.	.	151	158	220	68	270	568	435	1,690	625	30	27
12.	.	134	207	120	68	270	568	435	1,360	215	27	23
13.	.	104	185	155	60	500	540	435	780	147	31	22
14.	.	123	156	290	60	350	485	345	980	157	29	22
15.	.	174	139	920	60	310	512	285	540	162	29	22
16.	.	66	135	780	60	270	460	285	485	138	30	22
17.	.	60	101	640	60	350	435	248	412	152	23	22
18.	.	56	114	580	60	400	595	230	345	306	29	21
19.	.	56	130	370	60	240	625	200	305	248	27	21
20.	.	238	116	220	74	210	1,120	200	305	248	27	21
21.	.	171	120	165	74	210	1,050	153	216	145	23	19
22.	.	129	116	155	60	350	980	200	200	115	22	19
23.	.	92	121	460	48	560	780	655	180	103	20	18
24.	.	82	330	130	68	240	930	485	230	87	41	18
25.	.	77	270	110	60	210	435	300	265	73	65	18
26.	.	80	195	106	82	1,090	435	265	197	70	39	17
27.	.	77	148	90	920	1,760	435	280	265	76	30	17
28.	.	73	158	165	960	2,730	485	248	230	08	24	18
29.	.	70	109	82	-	1,440	300	2,140	167	58	26	10
30.	.	64	920	82	-	1,050	485	1,050	655	68	68	21
31.	.	61	130	100	-	910	-	540	-	56	03	-

Notes. — Stage-discharge relation affected by ice December 16 to March 24; discharge determined from study of stage-height graph, discharge measurements, weather records and comparison with similar study for Westfield River near Westfield.

Monthly Discharge of Westfield River at Knightville, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 162 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1915-16.					
October, ...	372	88	155.0	.967	1.10
November, ...	730	87	177.0	1.090	1.22
December, ...	2,280	120	404.0	2.490	2.87
January, ...	2,260	153	569.0	3.510	4.05
February, ...	2,580	192	535.0	3.300	3.56
March, ...	1,920	222	435.0	2.690	3.10
April, ...	2,060	730	1,160.0	7.160	7.99
May, ...	1,210	201	399.0	2.460	2.84
June, ...	670	134	303.0	1.870	2.09
July, ...	790	94	186.0	1.150	1.33
August, ...	310	36	92.0	.568	.66
September, ...	855	25	117.0	.722	.81
The year, ...	2,560	25	376.0	2.320	31.62
1916-17.					
October, ...	238	54	86.5	.534	.62
November, ...	1,050	94	197.0	1.220	1.36
December, ...	730	120	217.0	1.340	1.54
January, ...	920	82	265.0	1.640	1.89
February, ...	960	48	138.0	.852	.89
March, ...	2,730	165	645.0	3.980	4.59
April, ...	1,690	390	784.0	4.840	5.40
May, ...	2,140	183	503.0	3.100	3.57
June, ...	1,690	167	533.0	3.290	3.67
July, ...	625	56	142.0	.877	1.01
August, ...	68	20	38.7	.239	.28
September, ...	55	17	27.0	.167	.19
The year, ...	2,730	17	298.0	1.840	25.01

Westfield River near Westfield, Mass.

Location. — At the point known locally as Trap Rock Crossing, about 3 miles east of Westfield, 1 mile below the mouth of Big Brook, and 2 miles below the mouth of Westfield Little River.

Drainage Area. — Square miles, 496.

Records available. — June 27, 1914, to Sept. 30, 1917.

Gages. — Stevens continuous water-stage recorder on right bank, referenced to gage datum by means of a hook gage inside the well; an inclined staff gage is used for auxiliary readings.

Discharge Measurements. — Made from cable or by wading.

Channel and Control. — Channel covered with gravel and alluvial deposits; riffle of boulders about 200 feet below gage forms control at low and medium stages. At high stages control is probably formed by crest of storage dam at Mittineague, 3 miles below the station.

Extremes of Discharge. — Maximum stage during year ending Sept. 30, 1916, from water-stage recorder, 11.73 feet at 12 P.M. April 1 (discharge, 8,850 second-feet); minimum stage during year from water-stage recorder, 3.19 feet at 9 P.M. September 2 (discharge, 101 second-feet).

Maximum stage during year ending Sept. 30, 1917, from water-stage recorder, 14.46 feet at 2.30 A.M. March 28 (approximate discharge by extension of rating curve, 13,000 second-feet); minimum stage during year from water-stage recorder, 3.23 feet at 2 A.M. September 23 (discharge, 103 second-feet).

Maximum stage recorded, 1914-17, 17.4 feet on Aug. 4, 1915 (approximate discharge by extension of rating curve, 17,400 second-feet); minimum stage recorded, 3.02 feet on Sept. 24, 1914 (discharge, 46 second-feet).

Ice. — Stage-discharge relation usually affected by ice for short periods during the winter.

Diversions. — Water is diverted from Westfield Little River and carried to Springfield for municipal use.

Regulation. — Several power plants above the station cause some diurnal fluctuation of flow; the nearest dam is at Westfield.

Accuracy. — Stage-discharge relation practically permanent except during ice periods. Rating curve well defined. The operation of the water-stage recorder was satisfactory except for short periods, as shown in the footnotes to daily discharge tables.

Daily discharge ascertained as follows: Oct. 1, 1915, to July 2, 1916, by applying rating table to mean daily gage heights determined by planimeter; July 3, 1916, to Sept. 30, 1917, by discharge integrator. Results excellent.

Discharge Measurements of Westfield River near Westfield, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-foot).
1916.			
Jan. 20, ...	Hardin Thweatt, ...	4.83 ¹	530
Jan. 26, ...	Hardin Thweatt, ...	6.46	2,260
Mar. 25, ...	Hardin Thweatt, ...	4.49	668
Dec. 6, ...	A. H. Davison, ...	4.44	683
1917.			
Feb. 2, ...	A. H. Davison, ...	4.27 ¹	435
Aug. 14, ...	M. R. Stackpole, ...	3.52	172
Aug. 14, ...	M. R. Stackpole, ...	3.47	170

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Westfield River near Westfield, Mass., for the Year ending Sept. 30, 1916.

DAY.	1915.			1916.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	252	309	540	1,120	3,000	1,400	6,280	1,330	545	460	422	247
2.	232	292	445	1,120	2,210	1,190	6,850	1,160	495	390	387	172
3.	340	308	430	1,050	1,630	1,120	4,260	1,060	415	690	370	233
4.	330	288	415	990	1,360	1,020	3,430	980	830	768	290	141
5.	348	308	260	990	1,260	900	2,900	980	810	587	255	181
6.	390	300	360	1,830	1,260	810	3,100	930	1,020	525	258	226
7.	460	248	320	1,430	1,260	840	2,900	870	750	450	290	218
8.	500	300	340	1,050	930	900	2,350	1,020	666	408	355	220
9.	654	264	320	810	930	870	2,030	990	960	420	360	232
10.	465	248	300	750	900	870	1,910	930	1,080	625	432	131
11.	332	232	260	720	760	770	2,120	840	1,190	585	348	219
12.	320	248	280	660	720	690	3,210	720	1,160	515	271	227
13.	332	240	268	660	630	750	3,000	666	840	477	270	174
14.	312	194	320	690	580	654	3,780	565	760	690	274	181
15.	300	292	280	530	530	750	3,210	690	642	658	345	410
16.	372	690	292	530	530	638	3,210	750	720	430	237	1,990
17.	332	560	300	580	530	654	3,000	2,560	1,990	465	238	785
18.	345	430	430	580	480	690	2,800	2,600	1,670	418	237	498
19.	300	654	2,600	565	455	654	2,210	1,550	1,320	470	220	445
20.	328	1,070	2,120	480	455	690	2,120	1,190	1,360	375	263	315
21.	368	1,030	1,550	480	430	666	1,990	990	1,020	370	215	305
22.	360	780	1,190	900	405	648	2,080	870	930	480	213	265
23.	238	605	1,050	4,520	405	630	2,120	810	810	817	152	388
24.	248	540	960	2,120	405	666	2,600	900	720	628	375	360
25.	292	470	870	2,350	1,120	690	1,990	900	720	485	465	435
26.	300	485	4,850	1,830	6,280	840	1,910	750	960	840	387	335
27.	300	455	3,900	3,000	3,430	1,330	1,710	672	840	1,290	274	260
28.	490	400	2,500	5,860	2,400	1,950	1,710	670	666	1,270	265	248
29.	372	470	1,830	3,320	1,550	2,600	1,910	648	590	310	337	254
30.	352	606	1,430	1,990	-	3,000	1,550	680	600	552	290	806
31.	280	-	1,190	1,870	-	6,140	-	648	-	515	278	-

NOTE. — Stage-discharge relation affected by ice January 10 to 21 and February 13 to 24; estimates for these periods based on gage heights, two discharge measurements and weather records. No record by water-stage recorder, November 16 to 18, December 17 to 24, March 9, 10, and May 4 to 6; daily discharge for these periods estimated by comparison with records at Knight'sville and Goose Heights.

Daily Discharge, in Second-feet, of Westfield River near Westfield, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	610	280	1,780	460	480	2,200	3,700	1,060	1,360	670	210	330
2.	485	270	1,060	560	460	1,320	5,200	1,560	1,200	600	184	335
3.	310	325	790	490	450	1,020	3,200	1,360	1,100	530	205	215
4.	295	260	710	500	290	530	2,850	1,100	1,020	385	215	240
5.	290	265	660	560	400	790	2,850	1,400	830	445	235	265
6.	270	560	650	600	390	670	2,850	2,250	1,200	360	178	210
7.	260	505	600	1,220	380	600	2,750	2,200	2,100	365	205	190
8.	300	380	550	1,010	340	660	2,700	1,900	2,600	530	180	200
9.	192	420	505	780	280	820	2,300	1,720	1,500	315	184	275
10.	184	405	680	660	290	780	1,800	1,420	1,180	325	305	185
11.	200	335	590	640	280	780	1,600	1,100	3,760	630	220	156
12.	225	320	610	620	270	1,200	1,480	1,080	2,450	640	180	162
13.	260	325	480	930	270	1,140	1,440	1,020	1,720	540	180	172
14.	162	400	455	1,840	200	850	1,360	900	2,500	380	140	176
15.	310	360	370	1,340	260	930	1,320	810	1,600	485	220	200
16.	250	285	460	1,080	250	1,050	1,200	800	1,450	480	172	178
17.	196	280	400	860	230	1,220	1,420	760	1,280	480	158	194
18.	240	310	420	770	240	1,040	1,520	720	1,000	520	210	146
19.	455	370	430	680	220	840	2,050	630	850	530	180	146
20.	620	330	430	570	220	900	2,350	640	750	700	186	130
21.	365	250	490	610	210	1,060	2,250	610	640	530	180	136
22.	360	295	1,280	640	200	1,320	1,820	1,200	590	480	180	160
23.	225	1,940	1,140	510	220	2,900	1,300	1,360	580	450	230	125
24.	260	1,140	980	490	260	3,650	1,260	1,000	770	420	215	134
25.	275	620	1,000	500	390	3,800	1,120	830	620	380	230	136
26.	220	520	660	560	1,400	5,200	1,180	720	730	295	235	140
27.	285	490	630	370	3,950	8,700	1,220	750	720	300	220	152
28.	250	500	610	480	4,100	1,000	1,000	4,800	690	380	192	120
29.	245	1,560	570	460	3,000	980	980	2,400	950	200	335	175
30.	235	-	460	460	-	2,400	-	1,600	-	215	335	-
31.												

NOTE. — Stage-discharge relation affected by ice February 1 to 26; discharge determined from study of gage-height graph, one discharge measurement, weather records and comparison with similar study for Westfield River at Knightville. Discharge estimated because of no gage-height record April 6, 7, May 28 to 31, June 1, 2 and 17 to 23.

Monthly Discharge of Westfield River near Westfield, Mass., for the Two-year Period ending Sept. 30, 1917.

[Drainage area, 496 square miles.¹]

MONTH.	OBSERVED DISCHARGE IN SECOND-FEET.			Di- version from West- field Little River in Mil- lions of Gallons.	TOTAL DISCHARGE IN SECOND- FEET.		Run-off (Depth in Inches on Drain- age Area).
	Maxi- mum.	Mini- mum.	Mean.		Mean.	Per Square Mile.	
1915-16.							
October, ...	654	248	358	332.4	375	.756	.87
November, ...	1,670	184	487	309.3	503	1.010	1.13
December, ...	4,650	260	1,030	313.2	1,050	2.120	2.44
January, ...	5,860	480	1,490	362.1	1,500	3.020	3.45
February, ...	6,280	405	1,370	309.4	1,290	2.600	2.80
March, ...	6,140	630	1,190	346.4	1,210	2.440	2.81
April, ...	6,850	1,550	2,840	340.5	2,860	5.770	6.44
May, ...	2,600	565	995	354.2	1,010	2.040	2.35
June, ...	1,990	415	899	342.6	917	1.850	2.06
July, ...	1,290	370	586	362.3	604	1.220	1.41
August, ...	465	152	302	372.5	321	.647	.75
September, ...	1,990	131	364	350.3	382	.770	.86
The year, ...	6,850	131	982	4,095.2	999	2.010	27.40
1916-17.							
October, ...	620	162	291	397.9	311	.627	.72
November, ...	1,940	250	493	356.8	511	1.030	1.15
December, ...	1,780	370	676	360.9	694	1.400	1.61
January, ...	1,840	370	724	373.9	743	1.500	1.73
February, ...	3,930	200	472	348.7	491	.990	1.03
March, ...	8,700	600	1,830	369.2	1,850	3.730	4.30
April, ...	5,200	980	1,990	354.6	2,010	4.050	4.52
May, ...	4,800	610	1,320	360.7	1,340	2.700	3.11
June, ...	3,750	580	1,320	370.8	1,340	2.700	3.01
July, ...	700	200	446	385.7	465	.938	1.06
August, ...	335	140	211	416.2	232	.468	.54
September, ...	335	120	184	381.8	204	.411	.46
The year, ...	8,700	120	831	4,477.2	850	1.710	23.25

¹ Total area above station; not corrected for diversions.

Middle Branch of Westfield River at Goss Heights, Mass.

Location. — At highway bridge in Goss Heights, about $1\frac{1}{2}$ miles above village of Huntington, and half a mile above confluence of Middle and North branches of Westfield River.

Drainage Area. — Square miles, 53.

Records available. — July 14, 1910, to Sept. 30, 1917.

Gages. — Water-stage recorder on up-stream side of bridge abutment on right bank, referenced to gage datum by means of a hook gage inside of well. Inclined staff is used for auxiliary readings. Prior to Sept. 8, 1912, a chain gage on up-stream side of bridge was used.

Discharge Measurements. — Made from highway bridge or by wading.

Channel and Control. — Channel covered with coarse gravel and boulders; control somewhat shifting.

Extremes of Discharge. — Maximum open-water stage during year ending Sept. 30, 1916, from water-stage recorder, 5.7 feet at 8 A.M. December 26 (approximate discharge by extension of rating curve, 2,900 second-feet); a gage height of 7.7 feet was recorded on February 26, but channel was obstructed by ice at that time; minimum stage during year from water-stage recorder, 0.89 foot at 4 A.M. November 14 (discharge, 2.3 second-feet).

Maximum stage during year ending Sept. 30, 1917, from water-stage recorder, 3.82 feet at 6 P.M. April 1 (discharge, 1,330 second-feet); minimum stage during year from water-stage recorder, 0.76 foot at 10 A.M. September 29 (discharge, 4.8 second-feet).

Maximum open-water stage recorded, 1910–17, 5.38 feet on March 27, 1913 (approximate discharge, 2,600 second-feet); a gage height of 7.7 feet was recorded on Feb. 26, 1916, but channel was obstructed by ice at that time; minimum stage recorded, 0.78 foot on Sept. 20, 1914 (discharge, 0.3 second-foot).

Ice. — River usually frozen over during the greater part of the winter; ice jams occasionally form below the gage, causing several feet of backwater.

Regulation. — Flow somewhat affected at times by operation of small power plant about 2 miles above station.

Accuracy. — Stage-discharge relation changed during high water of January, 1916, and again during high water in March,

1917. Rating curve used previous to Jan. 22, 1916, well defined below 1,300 second-feet. Curve used Jan. 23, 1916, to March 24, 1917, well defined by discharge measurements below 400 second-feet, and very nearly parallel to the previous curve. Above 400 second-feet the new curve was extended as a parallel curve. Rating curve used March 24 to Sept. 30, 1917, fairly well defined by discharge measurements up to 1,000 second-feet. Stage-discharge relation seriously affected by ice from December to March, inclusive, during both years. Operation of water-stage recorders not entirely satisfactory. Daily discharge ascertained by applying rating table to mean daily gage heights determined by inspection of gage-height graph. Results fair.

Discharge Measurements of Middle Branch of Westfield River at Goss Heights, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
Dec. 23, ...	1915. Hardin Thweatt, ...	2.60 ¹	80.0
Jan. 25, ...	1916. Hardin Thweatt, ...	1.70	181.0
Jan. 26, ...	Hardin Thweatt, ...	2.04	317.0
May 12, ...	Hardin Thweatt, ...	1.22	70.0
May 12, ...	Hardin Thweatt, ...	1.22	70.0
June 1, ...	C. H. Pierce, ...	1.11	44.3
July 19, ...	Hardin Thweatt, ...	.92	19.1
Aug. 14, ...	H. W. Fear, ...	.84	12.2
Dec. 4, ...	A. H. Davison, ...	1.24	61.5
Dec. 4, ...	A. H. Davison, ...	1.24	61.5
Jan. 5, ...	1917. A. H. Davison, ...	1.84 ¹	46.0
Jan. 26, ...	Hardin Thweatt, ...	2.66 ¹	40.9
Feb. 3, ...	A. H. Davison, ...	2.54 ¹	27.8
Mar. 1, ...	A. H. Davison, ...	3.48 ¹	177.0
Mar. 28, ...	Hardin Thweatt, ...	3.22	927.0
Mar. 30, ...	Hardin Thweatt, ...	2.12	313.0
May 23, ...	Hardin Thweatt, ...	1.78	177.0
May 23, ...	Hardin Thweatt, ...	1.79	181.0
Aug. 8, ...	M. R. Stackpole, ...	.81	6.3
Aug. 8, ...	M. R. Stackpole, ...	.81	6.4
Aug. 17, ...	M. R. Stackpole, ...	.83	7.1

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Middle Branch of Westfield River at Cross Heights, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.			1916.								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.			23	124	510	228	1,030	143	54	30	22	12
2.	8.4	10	21	117	291	188	1,000	128	43	26	22	11
3.	8.0	5.6	12	104	220	188	1,000	115	60	78	20	9.5
4.	14	9.4	12	104	188	140	478	110	135	56	20	9.5
5.	15	6	12	124	143	125	440	100	84	40	18	9.5
6.	16	6.4	10	263	117	110	440	86	112	34	18	9.5
7.	18	6.4	9	173	93	86	415	80	70	26	18	9
8.	15	6	11	104	82	86	304	146	62	21	18	9
9.	35	5.2	12	80	72	78	262	107	100	30	30	9
10.	21	4.8	9	80	63	86	271	84	126	31	24	9
11.	16	4.8	9	92	58	66	271	78	158	31	18	9
12.	16	4.8	9	80	53	62	500	64	135	26	15	8
13.	6.4	2.9	12	104	50	58	658	56	93	76	14	8
14.	7.0	2.9	12	104	48	52	658	48	76	50	14	8
15.	12	14	12	33	48	48	598	60	64	34	12	50
16.	18	32	12	47	46	46	478	68	86	24	11	158
17.	18	12	80	47	46	44	470	530	238	19	30	56
18.	19	7.4	611	47	46	43	410	304	176	20	25	34
19.	19	7.4	742	47	46	41	291	191	126	20	15	28
20.	8.4	24	421	47	46	40	287	149	143	16	12	24
21.	12	106	421	47	46	38	271	126	106	21	11	20
22.	14	51	256	80	44	37	313	105	96	26	11	18
23.	12	33	158	221	44	35	450	146	72	26	11	18
24.	9.4	23	65	635	44	35	440	152	62	21	42	30
25.	11	20	57	255	44	35	440	152	62	21	42	30
26.	12	30	204	182	188	35	291	117	86	17	20	28
27.	8.9	18	1,040	340	1,370	43	262	98	107	40	18	22
28.	26	13	426	835	1,177	117	217	86	68	98	16	18
29.	23	13	238	946	1,585	255	234	80	54	100	14	16
30.	12	24	143	655	340	540	220	74	41	28	16	16
31.	12	33	130	220	-	835	170	70	34	24	13	-
	12	-	130	224	-	945	-	66	-	24	13	-

Notiz. — Stage-discharge relation affected by ice December 4 to 18, 21 to 24, January 7 to 22 and February 5 to March 29; estimates for these periods based on gage heights, three discharge measurements, weather records and comparison with other records in the Westfield River Basin. No record by water-stage recorder, July 30, 31, August 1 to 11, 23 to 27, September 11 to 15, 18 to 30; daily discharge for these periods estimated by comparison with records at Knightville and Westfield.

Daily Discharge, in Second-feet, of Middle Branch of Westfield River at Goss Heights, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.			1917.									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	
1.	60	28	145	25	40	175	759	112	104	37	8	10	
2.	35	43	110	66	22	145	642	186	96	35	8	8	
3.	30	35	94	78	23	105	438	123	86	28	9	8	
4.	28	28	80	62	27	72	365	90	70	24	10	7.5	
5.	26	43	70	46	26	74	338	182	61	21	8	7.5	
6.	20	62	82	250	28	78	314	200	182	18	7	7.5	
7.	18	56	70	160	22	82	340	225	328	17	7	7	
8.	17	48	68	82	20	120	350	219	296	17	6.5	9	
9.	16	43	62	62	17	160	370	182	142	15	7	8.5	
10.	15	43	105	52	16	130	175	120	139	14	8.5	8	
11.	15	43	62	28	14	105	139	100	346	19	8.5	8	
12.	14	34	72	26	13	145	142	101	532	44	7.5	7	
13.	13	27	62	35	12	130	129	96	293	35	7.5	7.5	
14.	12	31	85	62	11	160	129	70	282	26	7	7	
15.	25	43	64	380	10	145	120	66	305	24	7	7.5	
16.	15	32	50	300	10	130	109	56	172	32	7.5	6	
17.	14	38	46	100	9.5	160	109	51	139	32	7.5	7	
18.	14	28	43	120	8	130	162	47	104	37	8	6	
19.	16	35	40	94	8.5	120	215	44	177	44	8	6	
20.	64	32	37	72	8	82	355	41	61	54	8	5.4	
21.	40	31	35	62	8	43	332	37	48	58	7.5	6.7	
22.	27	28	82	55	7.5	82	396	37	48	28	7.5	5.4	
23.	24	43	220	62	7.5	160	197	44	40	21	7.5	6.7	
24.	22	380	145	62	10	160	142	132	24	17	7	6.7	
25.	20	160	105	43	17	400	104	104	43	14	8.5	5.4	
26.	25	92	62	41	62	435	86	60	41	14	9	5.4	
27.	22	90	43	28	365	465	101	60	30	12	7.5	5.4	
28.	20	92	62	26	435	880	104	83	54	12	6.5	5.4	
29.	18	66	46	24	435	400	86	658	35	11	6.5	6	
30.	17	350	37	35	-	320	93	265	70	10	9.5	6	
31.	16	-	26	52	-	310	-	142	-	9	13	-	

NOTE. — Stage-discharge relation affected by ice December 15 to March 24; discharge determined from study of gage-height graph, discharge measurements, weather records and comparison with similar study for Westfield River at Knightville. Discharge estimated by comparison with Westfield River at Knightville, because of no gage-height record, October 1 to 18, 24 to 31, November 1 to 9, 20 to 26, 30, December 5 to 14, March 28 to 29, April 7 to 10, July 1, 2, 17, and August 4 to 7.

*Monthly Discharge of Middle Branch of Westfield River at Goss Heights,
Mass., for the Two-year Period ending Sept. 30, 1917.*

[Drainage area, 53 square miles.]

MONTHS.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1915-16.					
October, ...	35	6.4	15.20	.287	.33
November, ...	109	2.9	17.70	.334	.37
December, ...	1,040	9.0	159.00	3.000	3.46
January, ...	965	38.0	211.00	3.980	4.59
February, ...	1,370	44.0	185.00	3.490	3.76
March, ...	965	35.0	153.00	2.890	3.33
April, ...	1,080	170.0	415.00	7.830	8.74
May, ...	520	48.0	121.00	2.280	2.63
June, ...	228	34.0	96.50	1.800	2.01
July, ...	100	17.0	34.60	.653	.75
August, ...	42	11.0	18.30	.345	.40
September, ...	158	8.0	25.00	.472	.53
The year, ...	1,370	2.9	120.00	2.260	30.90
1916-17.					
October, ...	64	12.0	23.10	.436	.50
November, ...	380	27.0	71.30	1.350	1.51
December, ...	220	28.0	72.40	1.370	1.58
January, ...	380	24.0	87.20	1.650	1.90
February, ...	435	7.5	45.70	.862	.90
March, ...	880	43.0	204.00	3.850	4.44
April, ...	759	86.0	238.00	4.490	5.01
May, ...	658	37.0	131.00	2.470	2.85
June, ...	532	30.0	138.00	2.600	2.90
July, ...	54	9.0	23.60	.445	.51
August, ...	13	6.5	7.92	.149	.17
September, ...	10	5.4	6.86	.129	.14
The year, ...	880	5.4	87.50	1.650	22.41

Farmington River near New Boston, Mass.

Location. — At highway bridge a quarter of a mile below Clam River and about 1 mile south of New Boston.

Drainage Area. — Square miles, 92.7.

Records available. — May 27, 1913, to Sept. 30, 1917.

Gages. — Barrett & Lawrence water-stage recorder on left bank, down-stream side of bridge, referenced to gage datum by a hook gage inside the well. Vertical staff on bridge abutment is used for auxiliary readings.

Discharge Measurements. — Made from a cable or by wading.

Channel and Control. — Channel rocky and filled with boulders; control practically permanent except as affected by removal of rocks in measuring section.

Extremes of Discharge. — Maximum open-water stage during year ending Sept. 30, 1916, from water-stage recorder, 6.82 feet at 10 A.M. December 26 (approximate discharge by extension of rating curve, 2,220 second-feet); minimum stage during year from water-stage recorder, 2.80 feet at 2 P.M. September 22 (discharge, 36 second-feet).

Maximum open-water stage during year ending Sept. 30, 1917, from water-stage recorder, 6.5 feet at 11 P.M. March 27 (discharge, 1,900 second-feet); a stage of 7.9 feet was recorded at 4 P.M. January 14, but the water was held back by an ice jam; minimum stage during year from water-stage recorder, 2.54 feet at 4 A.M. September 6 (discharge, 18 second-feet).

Maximum open-water stage from water-stage recorder, 1913-17, 7.64 feet on Oct. 26, 1913 (approximate discharge, 3,200 second-feet); minimum stage from water-stage recorder, 2.22 feet on Aug. 27, 1913 (discharge, 4.4 second-feet).

Ice. — River usually frozen over during greater part of winter; ice jams occasionally form below the gage, causing several feet of backwater.

Regulation. — Flow affected by storage in Otis Reservoir about 5 miles above New Boston, and by operation of a woodworking shop just above the station.

Accuracy. — Stage-discharge relation practically permanent except during ice periods. Rating curve well defined. The operation of water-stage recorder was satisfactory except for short periods, as shown in footnotes to daily discharge tables. Daily discharge ascertained by applying rating table to mean

daily gage heights determined by inspection of gage-height graph, or, for days of considerable fluctuation, by averaging the means of four-hour periods. Results only fair during winter, but good for open-water periods.

Discharge Measurements of Farmington River near New Boston, Mass., during the Two-year Period ending Sept. 30, 1917.

DATE.	Made by —	Gage Height (Feet).	Discharge (Second-feet).
Dec. 20, ... 1915.	Hardin Thweatt, ...	4.54	427
Jan. 21, ... 1916.	Hardin Thweatt, ...	4.06	253
Jan. 26, ... 1917.	H. H. Khachadoorian, ...	6.14 ¹	170
Aug. 11, ...	M. R. Stackpole, ...	3.27	97
Aug. 11, ...	M. R. Stackpole, ...	3.27	91

¹ Stage-discharge relation affected by ice.

Daily Discharge, in Second-feet, of Farmington River near New Boston, Mass., for the Year ending Sept. 30, 1916.

Day.	1915.				1916.								
	Oct.	Nov.	Dec.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	40	93	77		320	625	330	1,220	320	96	64	70	118
2.	51	84	68		320	435	224	1,220	238	88	63	63	118
3.	61	84	68		296	337	197	875	197	87	112	60	114
4.	65	82	66		296	254	141	710	224	161	131	60	114
5.	61	85	66		302	254	141	560	185	131	105	102	112
6.	88	78	63		415	238	162	560	173	151	99	110	114
7.	77	77	60		345	210	163	500	151	122	84	114	110
8.	107	75	56		296	163	131	445	151	118	77	122	107
9.	112	85	54		253	163	122	396	141	120	122	141	107
10.	98	47	52		224	151	112	356	141	118	141	120	108
11.	80	76	51		210	151	105	356	122	122	122	112	102
12.	81	77	50		185	151	105	500	114	131	107	107	99
13.	78	68	48		173	151	105	575	105	131	162	105	99
14.	75	85	47		173	141	98	710	100	122	337	105	98
15.	73	102	46		151	173	90	945	105	122	141	102	141
16.	45	141	45		151	151	90	710	114	131	105	102	320
17.	40	107	44		141	131	90	710	356	254	100	102	131
18.	39	104	238		141	112	100	635	356	299	105	98	141
19.	65	112	550		131	112	90	525	299	210	96	96	63
20.	65	299	455		151	131	90	455	210	210	80	94	51
21.	86	151	455		151	131	90	455	173	210	80	94	51
22.	56	122	395		254	122	100	415	173	173	99	96	46
23.	65	151	395		375	122	100	435	163	163	112	110	37
24.	65	98	337		575	105	100	525	185	141	108	123	40
25.	68	85	302		435	112	120	525	185	131	105	197	64
26.	94	75	254		375	210	110	478	163	141	93	141	52
27.	131	67	1,090		525	650	180	415	141	210	114	131	41
28.	163	65	875		840	525	180	415	141	210	114	131	41
29.	116	65	690		1,140	435	175	375	122	131	118	131	35
30.	112	67	525		710	415	240	375	122	100	94	131	46
31.	105	85	435		500	415	650	356	114	82	78	131	141
	100	-	375		455	-	990	-	114	-	70	122	-

NOTE. — Stage-discharge relation affected by ice December 7 to 18, January 9 to 20, February 13 to 26 and March 15 to 29; estimates for these periods based on stage heights, observer's notes, weather records and comparison of stage-height hydrograph with similar hydrographs for stations in near-by drainage basins. No record by water-stage recorder December 10 to 13 and April 7, 8, 18; daily discharge estimated by comparison with records at stations on near-by streams.

Daily Discharge, in Second-feet, of Farmington River near New Boston, Mass., for the Year ending Sept. 30, 1917.

Day.	1916.				1917.								
	Oct.	Nov.	Dec.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.	76	93	302		98	105	300	840	197	141	81	48	20
2.	62	102	197		90	105	160	980	224	131	65	49	21
3.	55	98	141		78	120	130	710	197	141	63	60	22
4.	53	94	120		78	140	110	675	162	122	60	93	22
5.	52	141	105		120	160	98	525	224	102	54	107	20
6.	62	162	104		185	160	120	455	356	131	49	131	19
7.	66	131	93		240	150	110	500	375	238	41	131	27
8.	141	122	80		155	140	130	415	320	288	36	131	65
9.	141	122	82		140	120	220	375	286	185	36	151	107
10.	141	113	88		140	105	120	266	238	131	36	173	99
11.	141	60	84		130	90	98	238	210	162	42	98	102
12.	141	48	93		120	78	130	254	197	455	70	131	102
13.	141	60	87		120	64	140	233	185	415	64	131	100
14.	141	131	86		300	60	130	234	162	269	46	122	102
15.	141	141	86		500	64	130	224	151	269	50	120	116
16.	151	131	76		460	73	140	210	151	286	73	118	116
17.	151	122	76		240	64	150	185	141	224	55	114	114
18.	141	122	74		120	60	140	238	141	185	94	104	112
19.	141	122	68		54	110	130	254	108	162	85	77	112
20.	197	122	70		64	98	120	337	99	131	94	122	110
21.	173	122	84		160	78	140	365	91	110	75	122	114
22.	63	120	105		185	64	130	435	94	94	68	122	112
23.	41	300	195		140	98	170	395	173	82	68	122	112
24.	100	269	173		140	120	435	320	173	71	94	131	118
25.	104	173	130		160	50	575	238	141	63	77	76	122
26.	106	112	105		160	120	625	197	116	60	58	64	122
27.	106	99	105		160	160	945	197	116	63	49	102	120
28.	102	82	105		140	400	1,310	197	141	91	44	107	118
29.	98	131	105		120	875	875	162	84	68	39	108	114
30.	94	105	98		600	600	480	162	269	81	36	122	87
31.	98	-	90		78	-	-	-	210	-	44	31	-

NOTE. — Stage-discharge relation affected by ice December 15 to March 22; discharge determined from study of gage-height graph, one discharge measurement, weather records and comparison with similar studies for near-by streams. Discharge November 22 and 23 estimated by comparison with Housatonic River near Great Barrington.

*Monthly Discharge of Farmington River near New Boston, Mass., for the
Two-year Period ending Sept. 30, 1917.*

[Drainage area, 92.7 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.
	Maximum.	Minimum.	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1915-16.					
October, ...	162	39	79.4	.857	.99
November, ...	269	47	93.7	1.010	1.13
December, ...	1,000	44	252.0	2.720	3.14
January, ...	1,140	131	349.0	3.760	4.34
February, ...	650	105	239.0	2.580	2.75
March, ...	980	90	177.0	1.910	2.20
April, ...	1,220	356	575.0	6.200	6.92
May, ...	356	100	174.0	1.880	2.17
June, ...	269	82	142.0	1.530	1.71
July, ...	337	63	113.0	1.220	1.41
August, ...	197	56	110.0	1.190	1.37
September, ...	320	35	96.9	1.050	1.17
The year, ...	1,220	35	200.0	2.160	29.33
1916-17.					
October, ...	197	41	110.0	1.190	1.37
November, ...	300	48	130.0	1.400	1.56
December, ...	302	68	110.0	1.190	1.37
January, ...	500	54	162.0	1.750	2.02
February, ...	400	50	119.0	1.280	1.33
March, ...	1,310	98	293.0	3.160	3.64
April, ...	980	162	359.0	3.870	4.32
May, ...	375	84	185.0	2.000	2.31
June, ...	455	60	164.0	1.770	1.98
July, ...	94	36	59.1	.638	.74
August, ...	173	31	107.0	1.150	1.33
September, ...	122	19	88.2	.951	1.06
The year, ...	1,310	19	157.0	1.690	23.03

Blackstone River at Albion, R. I.

Location. — At the dam of the Valley Falls Company in Albion, about 5 miles below the Massachusetts-Rhode Island State line, and $5\frac{1}{2}$ miles below the mouth of Branch River.

Drainage Area. — Square miles, 433 (321 square miles in Massachusetts and 112 square miles in Rhode Island).

Records available. — Oct. 1, 1914, to Sept. 30, 1916.

Gages. — Water-stage recorder on right bank of pond, 40 feet above the dam, installed Aug. 3, 1915; vertical staff at edge of pond 25 feet above dam, used prior to installation of water-stage recorder and for auxiliary readings; staff gage in canal near wheel intake, and staff gage in lower tailrace.

Computations of Discharge. — Flow over dam ascertained from rating curve based on current-meter measurements; discharge through wheels ascertained from measurements of flow in canal at various gate openings. Records are kept of wheel operations which are usually at full gate during working hours, variations in load being carried by an auxiliary steam plant.

Ice. — Little, if any, effect from ice.

Regulation. — At ordinary stages the flow is regulated by power plants, and held in storage by dams above the station, causing low flow during hours when mills are not in operation and on Sundays.

Co-operation. — Gage-height records for staff gages on pond, canal and tailrace, furnished by Mr. Arnold B. Chace of the Valley Falls Company.

Accuracy. — Stage-discharge relation for dam remained practically permanent until about Sept. 25, 1916, when operation of flashboards and sluice gates destroyed the value of the record; rating curve fairly well defined below 3,000 second-feet. Discharge-rating for wheels was approximate, as current-meter measurements made at different times did not agree closely. Open-water ratings used throughout the year. Staff gages on pond, canal and tailrace read 5 times daily at 6.15 A.M., 9 A.M., 11.30 A.M., 3 P.M. and 5.30 P.M. to half-tenths. Operation of water-stage recorder was satisfactory except from February 13 to March 24, when there was ice in the float well; gage heights from staff gage used during this period. Owing to lack of full information regarding wheel operation, and uncertainties in connection with rating of flow through the wheels, the values of daily discharge do not have a high degree of accuracy, but the values of mean monthly flow are fairly good.

*Monthly Discharge of Blackstone River at Albion, R. I., for the Years ending;
Sept. 30, 1914-16.*

[Drainage area, 433 square miles.]

MONTH.	DISCHARGE IN SECOND- FEET.		RUN-OFF.
	Mean.	Per Square Mile.	Depth in Inches on Drainage Area.
1914-15.			
October, ...	365	.843	.97
November, ...	296	.684	.76
December, ...	253	.584	.67
January, ...	1,090	2.520	2.90
February, ...	1,570	3.630	3.78
March, ...	771	1.780	2.05
April, ...	568	1.310	1.46
May, ...	340	.785	.90
June, ...	296	.694	.76
July, ...	465	1.070	1.23
August, ...	637	1.470	1.70
September, ...	168	.388	.43
The year, ...	562	1.300	17.61
1915-16.			
October, ...	148	.342	.39
November, ...	149	.344	.38
December, ...	533	1.230	1.42
January, ...	679	1.570	1.81
February, ...	1,090	2.520	2.72
March, ...	1,230	2.840	3.27
April, ...	1,800	4.160	4.64
May, ...	1,010	2.330	2.69
June, ...	1,120	2.590	2.89
July, ...	612	1.410	1.63
August, ...	327	.755	.87
September, ...	233	.538	.60
The year, ...	743	1.720	23.31

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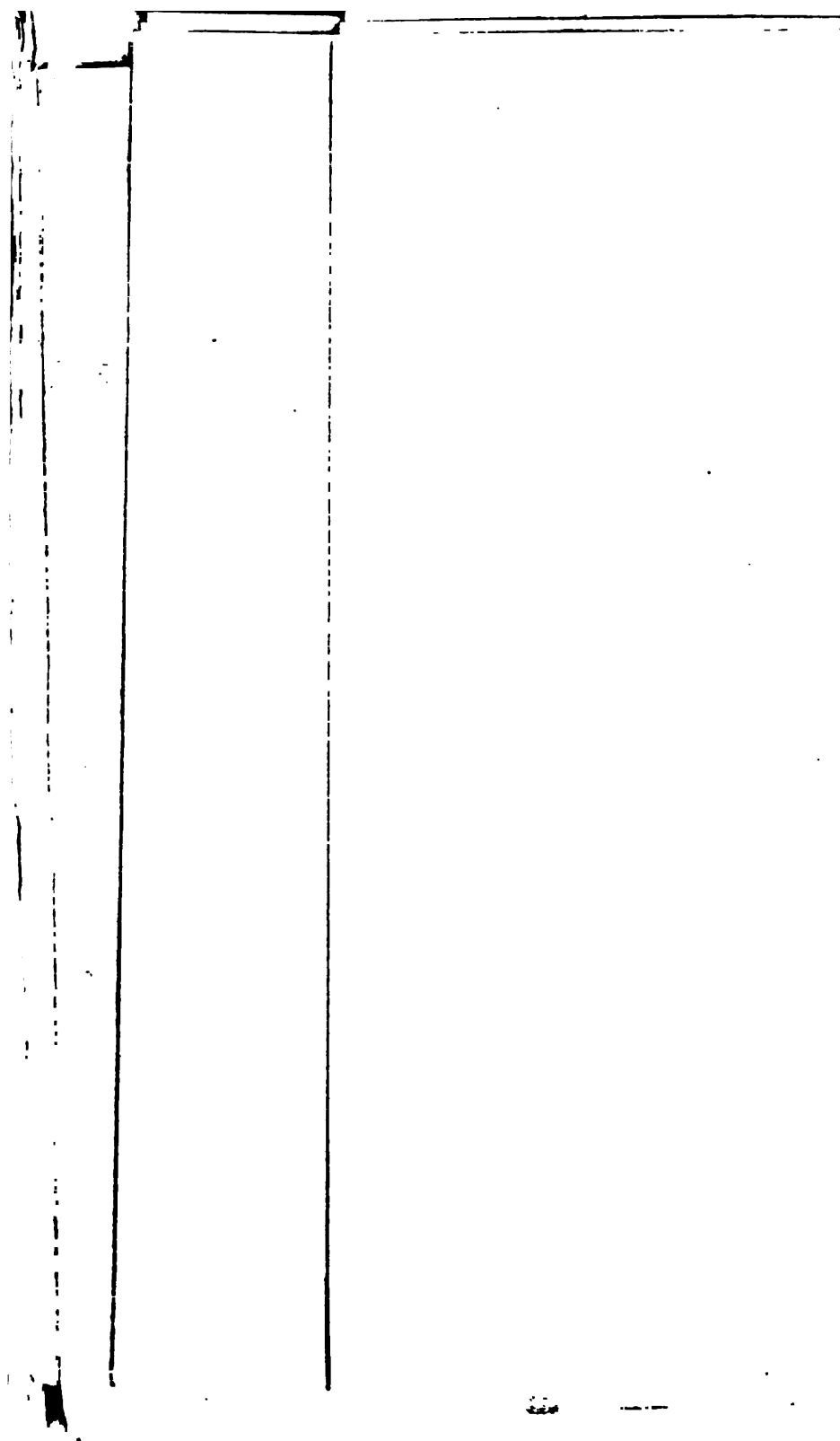
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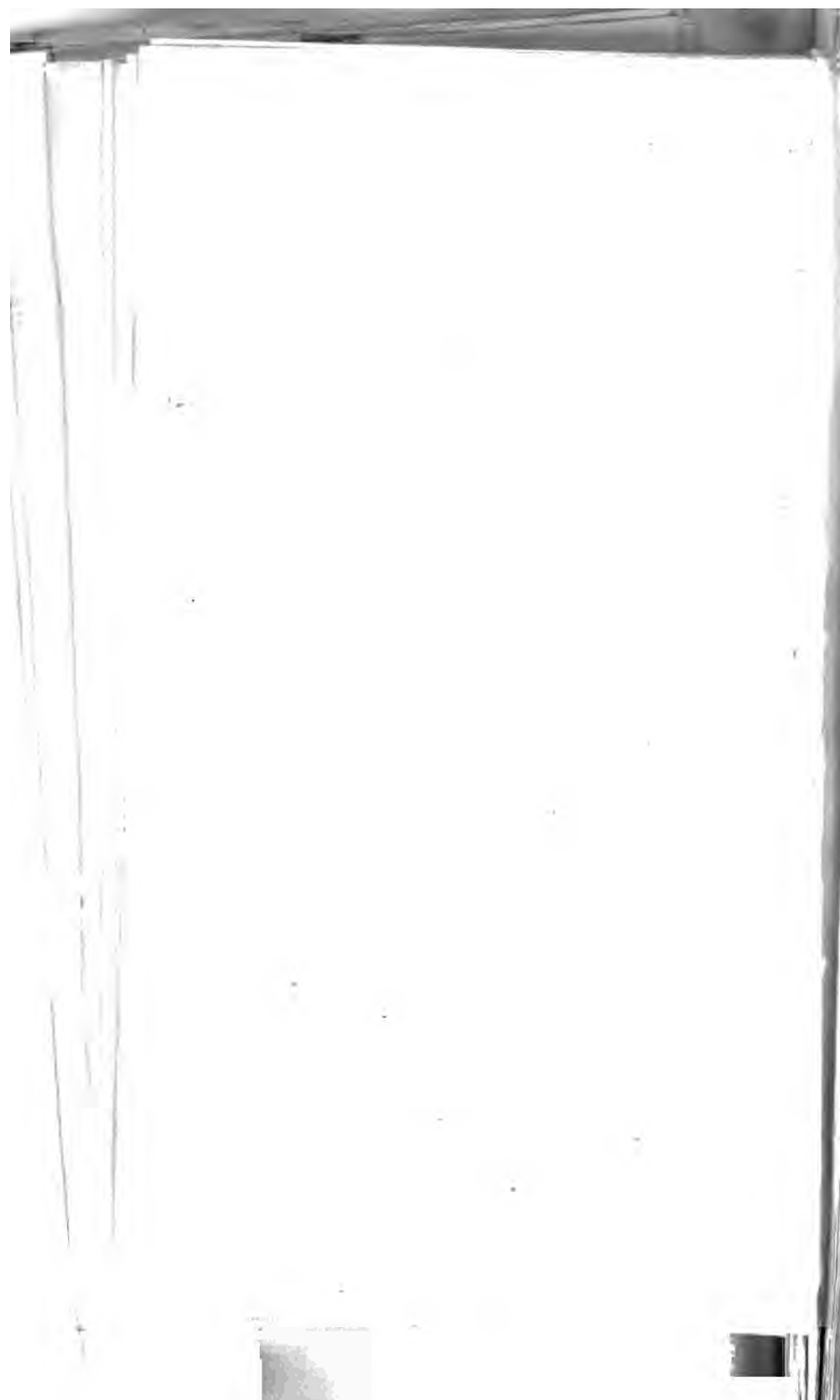
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